IMPACTS OF OIL AND GAS DEVELOPMENT ON RAPTORS ASSOCIATED WITH KEVIN RIM, MONTANA

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Prepared by A.R. Harmata, February 1991

INTRODUCTION

Kevin (pronounced Key'-vin) Rim, a sandstone escarpment located in north-central Montana, is important nesting habitat for a variety of raptors. The Bureau of Land Management (BLM) has identified the rim as both an "Area of Critical Environmental Concern" (ACEC) (Williams and Campbell 1988) and a "Key Raptor Area" (Olendorff et al. 1989). The ACEC designation recognizes that Kevin Rim has "more than locally significant qualities that give it special worth" and has "qualities that make it fragile, irreplaceable, unique, or endangered". Key Raptor Areas contain "unusually high nesting populations" and "require special consideration to avoid undue loss of commodity production (oil and gas etc.) or unjustifiable loss of raptor value".

During 1988, Kevin Rim supported 55 active raptor nests (Dubois 1988). Nesting density was among the highest recorded in the western U.S., with ferruginous hawks (Buteo regalis) and prairie falcons (Falco mexicanus) most common, representing 44% and 33% of the nesting population, respectively. The ferruginous hawk is a Category 2 Candidate for listing under the Endangered Species Act and both ferruginous hawk and prairie falcon are Species of Special Concern in Montana (Flath 1984). The golden eagle (Aquila chrysaetos), a Species of Special Concern in Montana and federally protected under the Eagle Protection Act of 1974 also nests on or near Kevin Rim.

Human activity associated with oil and gas development and agriculture occurs year-round within 1.6 km of Kevin Rim. Activities include daily maintenance of wells, exploration, drilling of new wells, off-road vehicle travel, field tilling, planting and harvesting. The Kevin-Sunburst Oil Field located directly below the cliffs of Kevin Rim likely will be in production for another 10-15 years. Although the BLM has identified the Kevin Rim as important raptor habitat, a site specific management plan has not been developed to prevent habitat degradation and protect raptors from potential human disturbance associated with the Kevin-Sunburst Oil Field and other agricultural or recreational activities.

Currently, BLM lands associated with Kevin Rim are managed under guidelines proposed in the Interagency Rocky Mountain Front Wildlife Monitoring/Evaluation Program Report (USDI 1987). However, Kevin Rim is at least 64 km from the area for which guidelines were developed and applicability of recommended buffer zones to conserve raptors is unknown. Efficacy of human activity on raptor productivity has not been evaluated at Kevin Rim and potential for habituation or increased sensitivity of raptors should be analyzed site specifically.

Baseline data and productivity of nesting raptors at Kevin Rim have been gathered (Dubois 1988), but neither nesting chronology nor food habits were determined. Foraging areas were not identified. High density of nesting raptors at Kevin Rim attest to its importance as quality habitat, but management of nesting substrate alone will not insure continued nesting success if prey base and foraging areas are not protected as well. Because several open evaporation pits associated with oil and gas development exist near Kevin Rim, contaminants pose another potential threat to prey and raptors.

In spring and summer 1990, an investigation was conducted to address these concerns. Raptor species of primary interest included ferruginous hawk, prairie falcon, golden eagle and great horned owl (Bubo virginianus). Other raptors of interest included American kestrel (Falco sparverius), Swainson's hawk (Buteo swainsoni), and red-tailed hawk (Buteo jamaicensis). Objectives of the study were:

1. Locate and describe all occupied nest sites.

2. Determine nesting chronology and productivity, and identify factors that may affect breeding success.

3. Determine food habits.

4. Determine habitat selection and use of nesting adult raptors.

5. Determine habitat use and dispersal of juvenile raptors during post-fledging period.

6. Assess habituation or sensitivity to oil and gas development and identify other potential conflicting land uses and human activities.

7. Quantify incidence of environmental contaminants in local raptors.

8. Develop management recommendations for raptors at Kevin Rim.

DESCRIPTION OF STUDY AREA

The Kevin Rim (hereafter referred to also as "the rim") is a prominent sandstone escarpment located approximately 8 km northwest of the town of Kevin in northcentral Montana ($48^{0}47'$ North, $112^{0}2'$ West). Associated cliffs attain heights of 35 m and extend 16 km in a north-south direction, generally facing east (Fig. 1). The rim and long (200 m), steep slopes below, combine with surrounding badlands to tower over adjacent rolling grasslands (1030 m mean sea level) by 220 m. Vegetative communities found in the study area are described in Appendix A. Climate is semi-arid, with extremes in temperature, precipitation and wind velocity often encountered daily.

Experimental (or impacted) and control areas were chosen in an effort to assess the effects of oil and gas development on reproductive performance and behavior of nesting raptors. The impacted area was designated Kevin Rim Raptor Study Area (KRSA) and included 26.7 km of escarpment, associated rim rock, erosional remnants and grassland within 5 km of the rim (Fig.1). Oil and gas extraction was the primary land use within KRSA with livestock grazing also occurring during summer months. Areas chosen as control contained as many ecological similarities as KRSA, but with minimal oil and gas development. Two control areas, Badlands and Buckley Coulee (Fig. 1) were established and data from each were combined before comparing with those from KRSA. Unless otherwise noted, the terms "control" or "control area" refer to Badlands and Buckley Coulee combined.

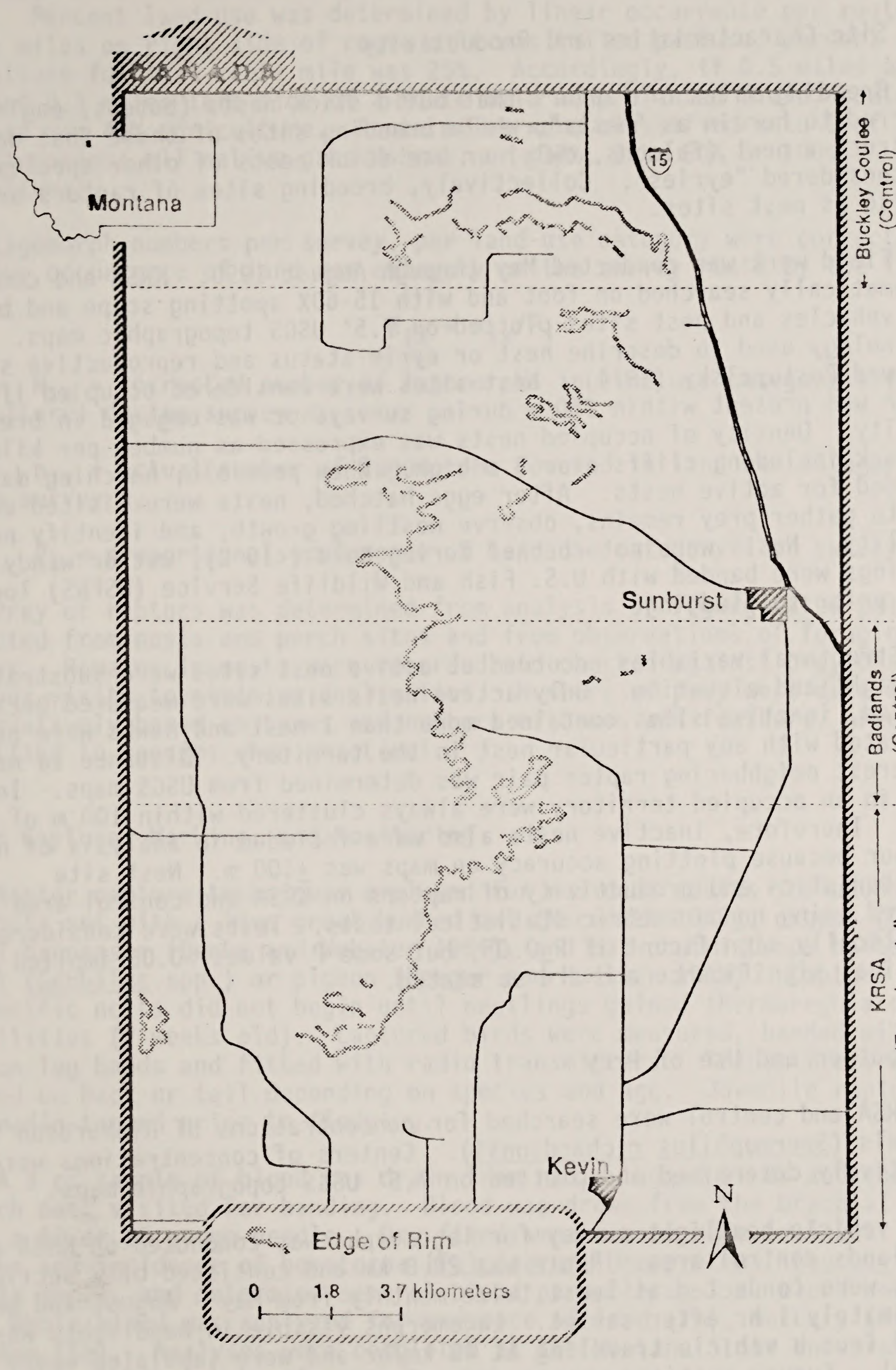


Figure 1. Location of Kevin Rim Raptor Study Area (KRSA) in Toole county, northern Montana and relationship to control areas Badlands and Buckley Coulee.

METHODS

Nest Site Characteristics and Productivity

Breeding sites of raptors that build stick nests (buteos, eagles) are referred to herein as "nests", while breeding sites of those that do not construct a nest (falcons, owls) or use stick nests of other species (owls) are considered "eyries". Collectively, breeding sites of raptors are referred to also as nest sites.

Field work was conducted May through August 1990. KRSA and control were systematically searched on foot and with 15-60X spotting scope and binoculars from vehicles and nest sites plotted on 7.5' USGS topographic maps. Terminology used to describe nest or eyrie status and reproductive success followed Postupalsky (1974). Nest sites were considered occupied if 1 adult raptor was present within 250 m during surveys or was engaged in breeding activity. Density of occupied nests was expressed as number per kilometer of rim rock including cliffs over 3 m high. When possible, hatching dates were recorded for active nests. After eggs hatched, nests were visited every 2-7 days to gather prey remains, observe nestling growth, and identify nestling mortality. Nests were not checked during cold (<10 C), wet or windy weather. Nestlings were banded with U.S. Fish and Wildlife Service (USFWS) lock-on leg bands prior to fledging.

Structural variables recorded at active nest sites were substrate type and height and elevation. Only active nests sites were measured because some occupied, inactive sites contained more than 1 nest and hawks were not associated with any particular nest in the territory. Distance to nest site of nearest neighboring raptor pair was determined from USGS maps. Inactive nests in an occupied territory were always clustered within 100 m of each other. Therefore, inactive nests also were included in analysis of nearest neighbor because plotting accuracy on maps was ±100 m. Nest site characteristics and productivity of raptors on KRSA and control area were analyzed using nonparametric statistical tests. Tests were considered statistically significant if $P \leq 0.05$, but some P values >0.05 implied biological significance and are so stated.

Distribution and Use of Prey

KRSA and control were searched for concentrations of Richardson's ground squirrels (*Spermophilus richardsonii*). Centers of concentrations were subjectively determined and plotted on 7.5' USGS topographic maps.

A vehicle headlight survey for lagomorphs was conducted on KRSA and part of Badlands control area. Route was 20.8 km and consisted of 2 sections. Surveys were conducted at least twice monthly from May - August and began approximately 1 hr after sunset. Lagomorphs visible in headlights were counted from a vehicle traveling at 48 km/hr and were tabulated every 1.6 km (1 mile). Survey sections were expressed in miles rather than km because of vehicle odometer calibrations and subsequent ease of analysis.

Survey route miles were classified by type and percent land use. Roadside land use was described as native grass/shrub or agricultural (tilled,

planted or fallow pastures) regardless of crop, within 50 m of the roadside. Each route mile driven actually contained 2 linear survey miles (both sides of road). Percent land use was determined by linear occurrence per route mile; if 0.5 miles on right side of route mile was tilled pasture, percent agriculture for that route mile was 25%. Accordingly, if 0.5 miles on right side and 0.3 miles left side of a route mile were planted field, route mile land use was 40% agriculture. Route miles were classified into 1 of 5 land use categories: all native grass/shrub; or ≤17%; 25%; 50% or 100% agricultural.

Lagomorph numbers per survey, per land use category were corrected for relative occurrence of land use category on the survey route by the formula:

$$N_{ix} = n_{ix}/P_i$$

where: N_{ix} = corrected number of lagomorphs in land use category i (i.e. 25% agriculture) during survey x,

n_{ix} = actual number of lagomorphs counted in land use category i during survey x,

P_i = proportional occurrence of land use category i on survey route

Prey of raptors was determined from analysis of regurgitated pellets collected from nests and perch sites and from observations of foraging raptors. Remains in nests were recorded and checked against prey observed on previous visits to minimize duplication. Numbers of prey were determined conservatively based on types and numbers of bones and feathers. Prey were identified to species when practical.

Raptor Capture, Marking, and Monitoring

Raptor capture techniques employed for resident adults included: dho-gaza nets set with a live great horned owl (Meredith 1943), pigeon (Columba livia) harnesses (Beebe and Webster 1964), and bal-chatri traps baited with a gerbil (Gerbilus spp.) or pigeon (Berger and Mueller 1959). Capture efforts at specific nests did not begin until nestlings gained thermoregulatory capabilities (2 weeks old). Captured birds were measured, banded with USFWS lock-on leg bands and fitted with radio transmitters. Transmitters were mounted on back or tail depending on species and age. Juvenile raptors also were radio-tagged prior to fledging.

A 3 cc sample of blood was drawn from radio-tagged birds and one nestling in each nest visited for banding. Blood was drawn from the brachial vein using a 22 or 25 gauge needle. Dry fixed smears were made to investigate species and incidence of hematozoa (Falciparum, Hemoproteus, Leucocytozoan, Babesia spp.), and determine several blood parameters, i.e. blood count, PCV etc. Whole blood was analyzed for presence of lead (Pb), mercury (Hg), and selenium (Se). Analyses were completed at the Montana State University Chemical Analytical Laboratory.

Attempts were made to monitor radio-tagged raptors so sample periods were evenly distributed over all daylight hours by season's end. Logistical problems and inadequate funding resulted in a less than optimal sampling

scheme. Raptors were located at the initiation of a tracking period by telemetry, then tracked visually for 4-6 hours, using telemetry to facilitate locations when out of sight. Juveniles were located daily after fledging, noting habitat and dispersal distances. Locations were plotted with a grease pencil on acetate covered 7.5′ USGS topographic maps and later transferred to tracing paper overlays for analyses.

Locations of nonradio-tagged raptors observed on KRSA and Badlands control area were plotted on 7.5 min USGS topographic maps. Only raptors observed >0.8 km away from nests were plotted in an attempt to identify foraging areas and assess habitat use.

Raptor Responses to Oil and Gas Development

To assess effects of oil and gas development on raptors, distance relationships of raptor nest sites, raptor locations and locations of assumed nonuse were compared to Habitat Component Variables (HCVs). HCVs chosen were considered representative of anthropogenic artifacts and perturbations in the environment related to energy development (e.g. roads, buildings, oil wells) and important natural components representative of nesting habitat and prey concentrations.

HCVs and respective acronyms chosen to analyze raptor habitat selection and effects of oil and gas development were dirt roads (DRTR), paved roads (PAVR), vehicle trails (TRAL), occupied buildings (OBLD), abandoned buildings (ABLD), active oil/gas wells (AWEL), inactive oil/gas wells (IWEL), oil storage tank (TANK), powerlines (POWR), ground squirrel concentrations (GRSQ), and top of Kevin Rim escarpment (KRIM). All HCV′s were digitized into either point (e.g. TANK) or line (e.g. DRTR) file categories on a VAX Scientific subsystem, DEC main frame computer at Montana State University.

Habitat relationships of occupied raptor nest sites in KRSA were compared to those of occupied raptor nest sites in control area and 25 systematically distributed points of assumed nonuse along the rim in KRSA (Appendix Fig. 1). Systematic points were evenly distributed along the rim in order to accurately sample distribution of HCVs.

Locations of radio-tagged birds monitored sufficiently to permit analysis were weighted based on frequency and duration of use employing the formula:

$$W_x = \mathrm{lnx}[\{F_p^2(T_p)\}/T_m]$$

where: W_x = weight$_x$ for F_p 1,

F_p = number times that perch was used,

T_p = total time in minutes that perch was used,

T_m = total monitoring time in hours.

W_x was always a whole number and determined frequency a location was used in analysis. Locations of nonradio-tagged raptors were not weighted, hence all were assigned a frequency of 1. Habitat associated with used locations

was compared to habitat associations of 137 points of assumed nonuse systematically distributed throughout KRSA and Badlands (Appendix Fig. 2).

Habitat relationships of locations of raptors were analyzed by employing GEOSCAN (MDFWP 1983), a computer based program that analyzes animal locations in the context of specific habitat components. GEOSCAN subprograms measured minimum distances among locations of use and nonuse and respective HCVs. Stepwise discriminant analysis (Program P7M: Dixon 1981) was employed to detect differences between mean distances of habitat components for used and nonused locations.

Powerline Survey

A powerline survey for dead raptors was conducted on foot once a month from May to August. Dead raptors were identified to species, aged, and their location plotted on 7.5′ USGS topographic maps.

RESULTS

Nesting Population and Nest Site Selection

Fifty-five occupied raptor territories were located during 1990 (Figs. 2-5; Table 1). Precise locations are presented in Appendix Table 1. In all instances, raptors nested closer to other raptorial species than conspecifics (Table 2). Ferruginous hawks and prairie falcons nested closer to other raptors in KRSA than control but great horned owls and golden eagles nested farther from other raptors in KRSA than control. Most ferruginous hawk nests were located in KRSA (Fig. 2) where nesting density per km of rim rock was 0.41/km. Nesting density in Badlands and Buckley Coulee was 0.70/km and 0.11/km, respectively, and 0.38/km combined. Prairie falcon eyries were also most numerous in KRSA, containing 53% of total found. Density was 0.34/km in KRSA, 0.14/km in Badlands, 0.23/km in Buckley Coulee, and 0.19/km in combined control. Great horned owl nesting density was 0.11/km in KRSA, 0.0 in Badlands and 0.10/km in Buckley Coulee. Golden eagle nesting density was 0.075 in KRSA, 0.07/km Badlands and 0.057/km in Buckley Coulee.

Structural characteristics of active nest sites on KRSA and control were not compared statistically due to small sample sizes. However, cliff and nest heights were consistently higher in KRSA than control (Table 3).

Amount of each HCV within KRSA and controls is presented in Table 4. Distribution and number of HCVs are shown in Appendix Figures 3-13. Comparison of minimum distances of 11 HCVs to occupied ferruginous hawk nest sites and prairie falcon eyries in KRSA and control detected significant differences. Ferruginous hawk nest sites in KRSA were significantly closer to IWEL, TANK and DRTR (Table 5) while prairie falcon eyries were closer to IWEL and TANK (Table 6). Few inactive wells or oil tanks were present in controls, indeed that was the primary reason for choosing the area as control. One dirt road ran down the middle of the relatively narrow Buckley Coulee. Buckley Coulee was relatively narrow and all raptor nests were therefore quite close to a dirt road.

Comparison of minimum distances of 11 HCVs to occupied ferruginous hawk nests sites and 25 systematically located points along the rim in KRSA showed significant differences between the 2 groups ($P<0.01$; Kruskal-Wallis Test). Pairwise comparisons showed significant differences between systematic locations and occupied nest locations for distances to both natural HCVs (KRIM, GRSQ) and 2 human activity related HCV's, IWEL and OBLD ($P<0.05$;Table 7). Distances of occupied hawk nests were farther from KRIM than systematically located points but the result is certainly a function of sampling design. However, occupied hawk nests were located an average of 141 m away from large cliffs and illustrates the propensity for ferruginous hawks to nest on lower, smaller cliffs (Table 7).

Occupied ferruginous hawk nests in KRSA were significantly closer to GRSQ than systematic locations along the rim ($P=0.02$). On average, occupied nests were 345 m closer to ground squirrel concentrations than systematic points but hawk nests were also 109 m from the rim top. Curiously, occupied nests were significantly closer to OBLD than systematic points ($P<0.01$).

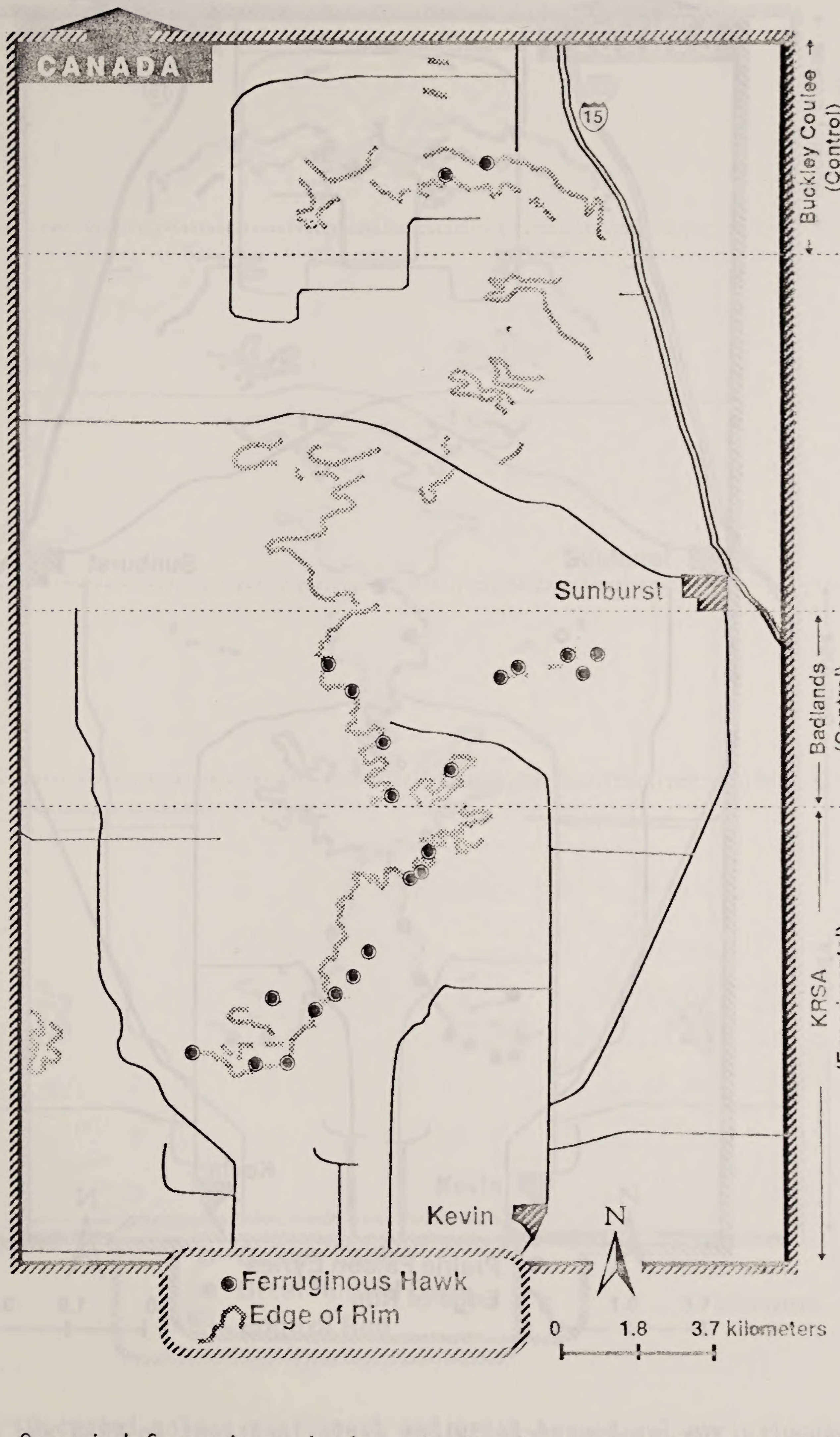


Figure 2. Occupied ferruginous hawk nest site locations in KRSA and control areas, 1990.

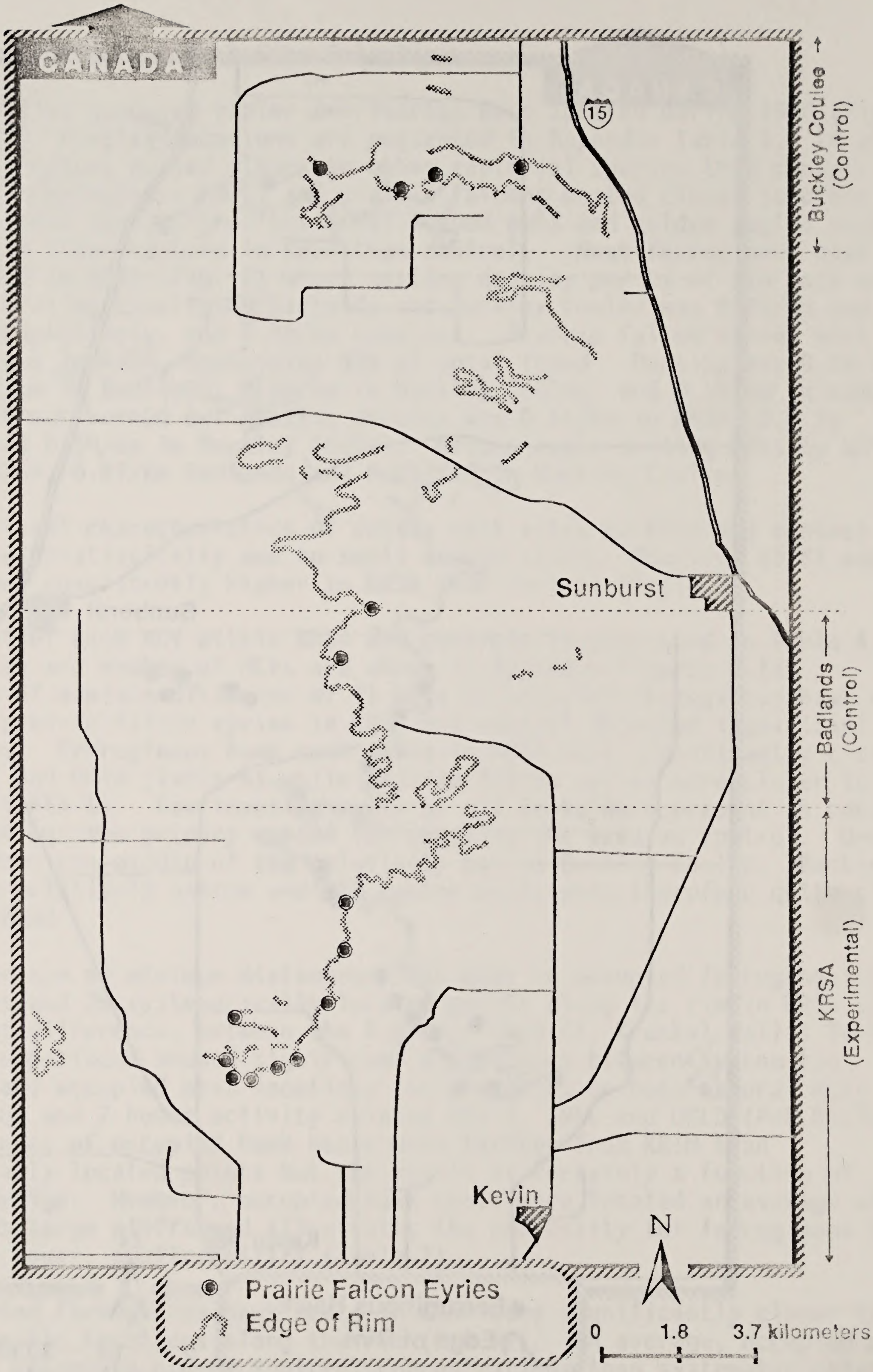


Figure 3. Occupied prairie falcon eyrie locations in KRSA and control areas, 1990.

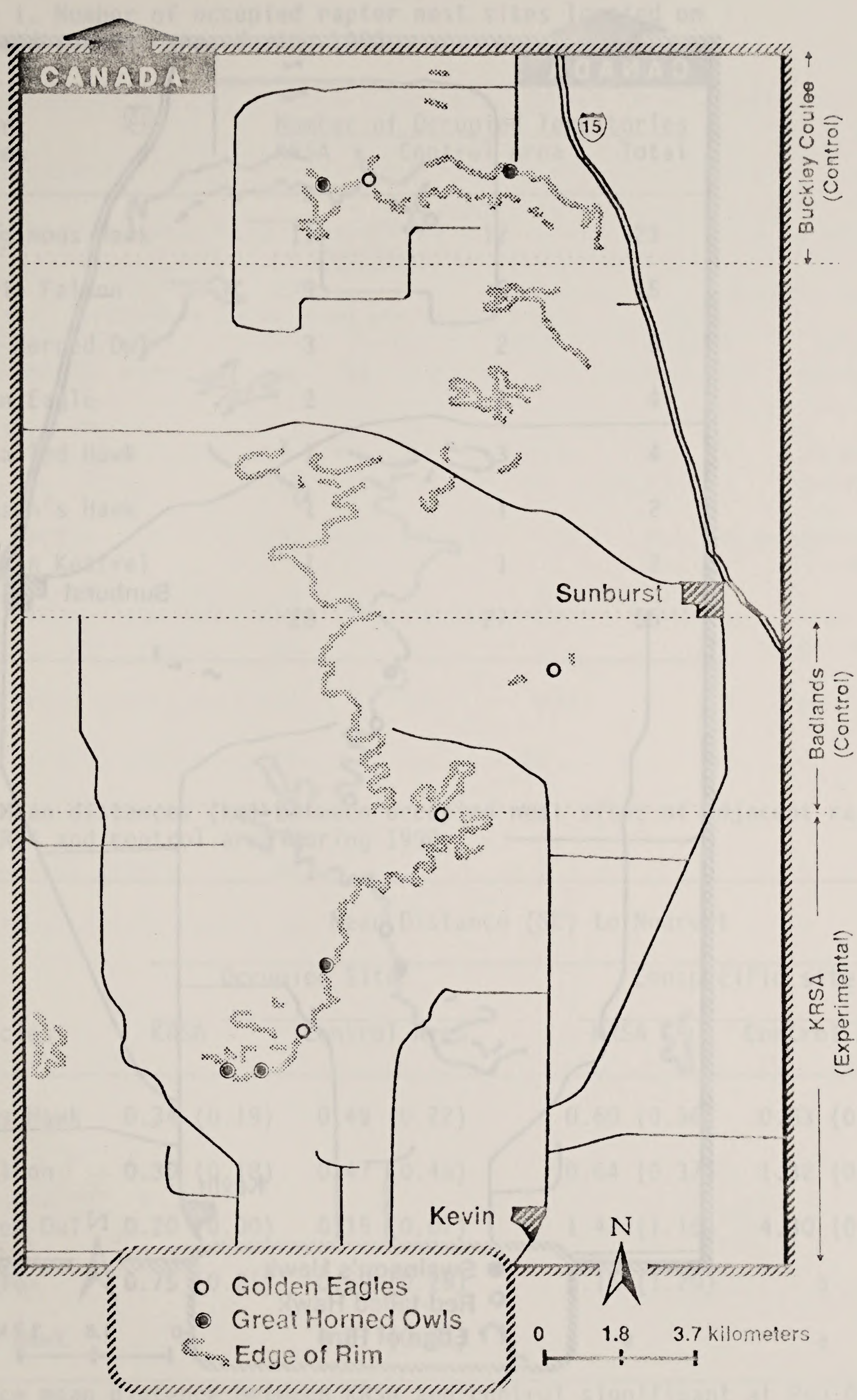


Figure 4. Occupied golden eagle nest and great horned owl eyrie locations in KRSA and control areas, 1990.

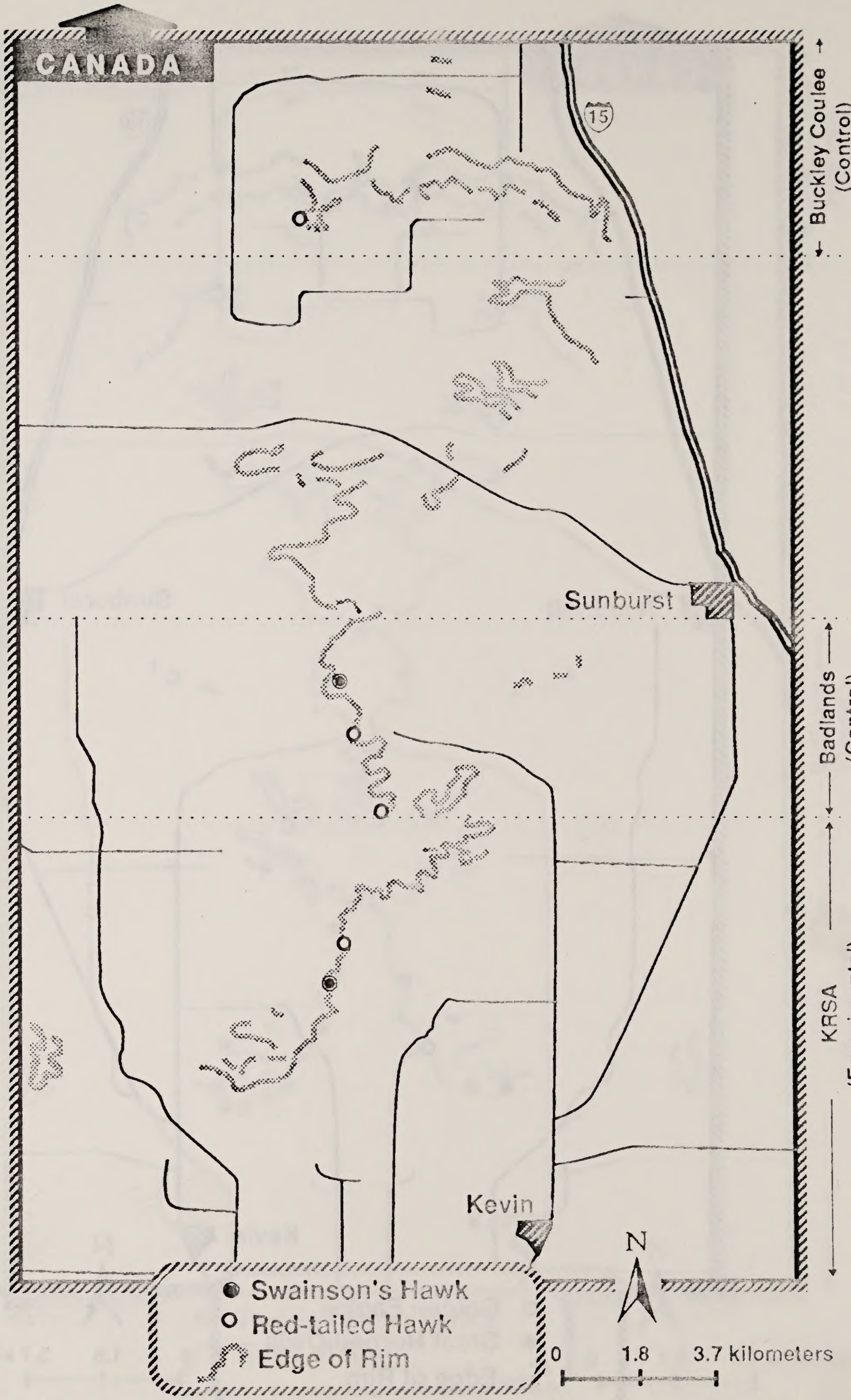


Figure 5. Occupied red-tailed and Swainson's hawk nest site locations in KRSA and control areas, 1990.

Table 1. Number of occupied raptor nest sites located on KRSA and control area during 1990.

Raptor Species	Number of Occupied Territories KRSA	Control Area	Total
Ferruginous Hawk	11	12	23
Prairie Falcon	9	6	15
Great Horned Owl	3	2	5
Golden Eagle	2	2	4
Red-tailed Hawk	1	3	4
Swainson's Hawk	1	1	2
American Kestrel	1	1	2
Total	28	27	55

Table 2. Mean distances (km) between occupied nest sites of adjacent raptor pairs on KRSA and control area during 1990.

	Mean Distance (SD) to Nearest			
	Occupied Site		Conspecific site	
Raptor Species	KRSA	Control Area	KRSA	Control Area
Ferruginous Hawk	0.34 (0.19)	0.49 (0.22)	0.60 (0.36)	0.83 (0.34)
Prairie Falcon	0.30 (0.18)	0.47 (0.46)	0.64 (0.37)	1.32 (0.56*)
Great Horned Owl	0.20 (0.00)	0.15 (0.07)	1.47 (1.16)	4.30 (0.00)
Golden Eagle	0.75 (0.21)	0.60 (0.28)	5.15 (1.20)	a
Red-tailed Hawk	a	0.67 (0.42)	a	a

* Difference mean distance between KRSA and control significant at P<0.05.

a insufficient sample size for comparison

Table 3. Nest site characteristics of cliff nesting raptors on KRSA and control area during 1990.

Raptor Species	Number of Nests KRSA	Number of Nests Control	Height of Substrate (m) KRSA mean	SD	Height of Substrate (m) Control mean	SD	Height of Nest (m) KRSA mean	SD	Height of Nest (m) Control mean	SD	Percent of Substrate KRSA mean	SD	Percent of Substrate Control mean	SD
Prairie Falcon	6	4	14.9	7.7	8.8	3.8	9.6	6.6	6.8	3.6	62.3	23.1	74.1	11.8
Ferruginous Hawk	6	3	20.3	14.2	7.2	2.0	8.0	3.5	4.2	1.2	60.1	28.7	58.5	1.7
Great Horned Owl	2	1	9.3	3.8	9.6		7.1	2.8	6.6		76.2	1.6	68.8	
Golden Eagle	1	1	18.9		16.5		11.4		9.0		60.3		54.5	

Table 4. Amount of Habitat Component Variables (HCVs) in KRSA and control areas.

	Number in Study Area (km)					
HCV	KRSA		Badlands		Buckley Coulee	
Dirt Roads (DRTR)	10	(59.4)	3	(13.6)	3	(19.8)
Paved Roads (PAVR)	1	(12.3)	1	(9.4)	1	(14.9)
Vehicle Trails (TRLR)	120	(149.7)	15	(40.6)	16	(35.5)
Powerlines (POWL)	17	(37.4)	Not Recorded			
Summit of Kevin Rim (KRIM)	8	(26.7)	5	(14.3)	22	(17.5)
Active Oil/gas Well (AWEL)	93		0		0	
Inactive Oil/gas Well (IWEL)	91		2		0	
Abandoned Building (ABLD)	39		12		9	
Occupied Building (OBLD)	25		0		26	
Oil Storage Tank (TANK)	48		1		0	
Ground Squirrel Colony (GRSQ)	38		0		0	

Table 5. Mean minimum distance (m) of occupied ferruginous hawk nests from selected Habitat Component Variables (HCVs) in KRSA and control area, 1990.

HCV[1]	KRSA mean	KRSA SD	Control Area mean	Control Area SD	P-Value
	Minimum Distance (m)				
PAVR	6470	1653	6412	2833	0.93
DRTR	2024	552	1555	752	0.03
TRLR	317	153	486	291	0.06
OBLD & ABLD	1466	432	1253	509	0.36
AWEL	792	260	a		--
IWEL	793	310	2220	682	0.00
TANK	1100	399	6044	2448	0.00
POWL	798	309	a		--
GRSQ	1025	273	a		--
KRIM	141	227	152	207	0.41

[1]PAVR-paved roads, DRTR-dirt roads, TRLR-vehicle trails, OBLD-occupied buildings, ABLD-abandoned buildings, AWEL-active oil/gas well, IWEL-inactive oil/gas well, TANK-oil storage tank, POWL-powerlines, GRSQ-ground squirrel concentrations, KRIM-summit of Kevin Rim.

a None present.

Table 6. Mean minimum distance (m) of occupied prairie falcon eyries from Habitat Component Variables (HCVs) in KRSA and control area, 1990.

	Minimum Distance (m)				
	KRSA		Control Area		
HCV[1]	mean	SD	mean	SD	P-Value
PAVR	5451	1430	5651	3263	0.77
DRTR	2012	506	1400	904	0.18
TRLR	229	115	249	131	0.68
OBLD & ABLD	1541	601	1009	545	0.11
AWEL	724	194	a		--
IWEL	743	290	1628	1105	0.05
TANK	1056	462	>8800		0.00
POWL	766	302	a		--
GRSQ	1025	273	b		--
KRIM	24	22	37	22	0.22

[1]PAVR-paved roads, DRTR-dirt roads, TRLR-vehicle trails, OBLD-occupied buildings, ABLD-abandoned buildings, AWEL-active oil/gas well, IWEL-inactive oil/gas well, TANK-oil storage tank, POWL-powerlines, GRSQ-ground squirrel concentrations, KRIM-summit of Kevin Rim.

a None present.

b None known.

Table 7. Mean minimum distance (m) of points of assumed nonuse systematically located along the summit of Kevin Rim escarpment and occupied nest sites of cliff nesting raptors to 11 Habitat Component Variables in KRSA in 1990.

	Habitat Component Variable (HCV)[1]							
	DRTR		PAVR		TRLR		POWL	
Location	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Ferruginous Hawk (n=11)	2024	552	6470	1653	317	153	798	309
Prairie Falcon (n=9)	2012	506	5451	1430*	229	115	766	302
Golden Eagle (n=1)	2168		5290		162		329	
Great Horned Owl (n=3)	1911	443*	5207	1343*	222	99	944	478
Random point (n=25)	2271	518	6650	1753	287	193	961	498

*Difference of mean distance between nest sites and nonuse points significant at P<0.05.

[1]PAVR-paved roads, DRTR-dirt roads, TRLR-vehicle trails, OBLD-occupied buildings, ABLD-abandoned buildings, AWEL-active oil/gas well, IWEL-inactive oil/gas well, TANK-oil storage tank, POWL-powerlines, GRSQ-ground squirrel concentrations, KRIM-summit of Kevin Rim.

Table 7, cont'd. Mean minimum distance (m) of points of assumed nonuse systematically located along the summit of Kevin Rim escarpment and occupied nest sites of cliff nesting raptors to 11 Habitat Component Variables in KRSA in 1990.

	Habitat component Variable (HCV)[1]							
	KRIM		AWEL		IWEL		TANK	
Location	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Ferruginous Hawk (n=11)	141	227*	792	260	793	310*	1100	399
Prairie Falcon (n=9)	24	22	724	194	743	290	1056	462
Golden Eagle (n=1)	15		1119		1181		838	
Great Horned Owl (n=3)	22	18*	614	148*	470	69*	1135	782
Random point (n=25)	34	84	792	260	731	350	1145	473

*Difference of mean distance between nest sites and nonuse points significant at P<0.05.

[1]PAVR-paved roads, DRTR-dirt roads, TRLR-vehicle trails, OBLD-occupied buildings, ABLD-abandoned buildings, AWEL-active oil/gas well, IWEL-inactive oil/gas well, TANK-oil storage tank, POWL-powerlines, GRSQ-ground squirrel concentrations, KRIM-summit of Kevin Rim.

Table 7, cont'd. Mean minimum distance (m) of points of assumed nonuse systematically located along the summit of Kevin Rim escarpment and occupied nest sites of cliff nesting raptors to 11 Habitat Component Variables in KRSA in 1990.

	Habitat Component Variable (HCV)[1]					
	OBLD		ABLD		GRSQ	
Location	Mean	SD	Mean	SD	Mean	SD
Ferruginous Hawk (n=11)	3119	910*	1481	441	1025	273*
Prairie Falcon (n=9)	2486	995*	1718	681	854	207*
Golden Eagle (n=1)	2846		979		968	
Great Horned Owl (n=3)	2317	1159*	1712	870	757	229*
Random point (n=25)	6034	1393	1725	637	1379	491

*Difference of mean distance between nest sites and nonuse points significant at P<0.05.

[1]PAVR-paved roads, DRTR-dirt roads, TRLR-vehicle trails, OBLD-occupied buildings, ABLD-abandoned buildings, AWEL-active oil/gas well, IWEL-inactive oil/gas well, TANK-oil storage tank, POWL-powerlines, GRSQ-ground squirrel concentrations, KRIM-summit of Kevin Rim.

Comparison of minimum distances of 11 HCVs to occupied prairie falcon eyries and 25 systematic locations along the rim in KRSA showed significant differences between the 2 groups ($P<0.05$; Kruskal-Wallis test). Pairwise comparisons indicated significant differences between systematic locations and occupied eyries for distances to both natural and human activity related HCVs ($P<0.05$). Occupied eyries were located significantly closer than systematic locations to GRSQ, OBLD and PAVR ($P<0.05$; Kruskal-Wallis test;Table 7).

Samples of occupied golden eagle and great horned owl nests were too small to make valid comparisons but trends were evident (Table 7). Large differences were notable in distances of occupied owl nests from HCVs DRTR, IWEL, and OBLD. All 3 occupied owl nests were located closer to respective HCVs than systematic locations. The active golden eagle nest was closer than systematic locations to all HCVs except AWEL. The active golden eagle nest was consistently closer than the inactive nest to all HCVs except AWEL.

Nesting Chronology

Back dating from known fledging dates (N=9) indicated ferruginous hawks laid eggs during the last week of April. Eggs hatched during late May and young fledged in early to mid-July. Prairie falcons laid eggs the last week of April. Eggs hatched in late May and young fledged during the first week of July (N=8). Golden eagles laid eggs in mid-March. Eggs hatched during the last week of April and young fledged during the first week of July (N=2). Great horned owl young fledged in late June and early July, although exact dates were not determined.

Raptor Productivity

On both KRSA and control, prairie falcons were most productive and golden eagles least productive (Table 8). Ferruginous hawks and red-tailed hawks were more productive in KRSA than control but opposite was true for prairie falcons and great horned owls. Golden eagles were equally productive in both areas.

Stepwise multiple regression analysis (program MREGRESS; Lund 1988) detected significant correlations of number of young fledged per active ferruginous hawk pair to proximity of HCVs to their nest in KRSA. Most significant regression involved inclusion of POWL, AWEL, GRSQ, and IWEL in the model ($P=0.031$; $R^2=0.844$). Pearson correlations were negative for GRSQ and IWEL, suggesting more productive hawk pairs tended to nest closer to ground squirrel concentrations and inactive wells, while farther from active oil wells and powerlines.

Grouping ferruginous hawk pairs into productivity (no. fledged per active eyrie) categories of "high" ($\geq$3 young fledged) or "low" ($\leq$2 young fledged) showed similar results. Ferruginous hawk pairs nesting farther from active wells had significantly higher productivity than those located closer ($P=0.012$). Mean distance of ferruginous hawk nests of high productivity to AWEL was 1159 m while distance from nests of low productivity was only 690 m. Hawks nesting closer to powerlines tended to have lower productivity than those nesting farther away ($P=0.037$). Mean distance of ferruginous hawk nests

Table 8. Productivity of raptor nests with known outcome on KRSA and control area during 1990.

Raptor Species	Productivity[a] KRSA (N)	Control area (N)
Ferruginous Hawk	2.60 (10)	0.08 (10) *
Prairie Falcon	2.75 (8)	4.25 (4)
Golden Eagle	0.50 (2)	0.50 (2) b
Red-tailed Hawk	2.00 (1)	1.50 (2) b
Swainson's Hawk		3.00 (1)
Great Horned Owl	1.00 (3)	2.50 (2) b

* P<0.05

a Number young fledged per occupied site.

b N insufficient for comparison.

of high productivity to POWL was 1087 m while distance from nests of low productivity was only 664 m. Proximity to other HCVs appeared to have no correlation with ferruginous hawk productivity.

Stepwise multiple regression analysis of prairie falcon productivity in KRSA with HCVs (POWL, AWEL, IWEL, TANK, OBLD, ABLD) showed significant relationships to DRTR, IWEL, TANK, and GRSQ ($P=0.011$; $R^2=0.974$). Prairie falcon eyries that produced more young tended to be farther from IWEL, TANK and GRSQ but closer to DRTR. Grouping nests into high (≥ 3) and low (0) productivity, no significant differences were found among distances of groups to respective HCVs. Small sample sizes of productive golden eagle and great horned owl eyries prevented statistical analysis with HCVs.

Use and Distribution of Prey

Prey remains collected from ferruginous hawk, golden eagle, prairie falcon, and great horned owl nesting territories are listed in Tables 9-12. Raptors nesting on KRSA preyed proportionately more on ground squirrels ($P<0.01$) and lagomorphs but less on birds ($P<0.03$) than raptors nesting on the control area . However, ferruginous hawks preyed proportionately less on ground squirrels and more on birds in the KRSA than control, but not significantly so. Golden eagles on KRSA preyed proportionately less on birds than eagles on the control area ($P<0.01$) but eagles on KRSA consumed more ground squirrels than those on the control ($P=0.07$). Prairie falcons on KRSA preyed proportionately less on birds than those on the control area ($P=0.09$). Great horned owls nesting on KRSA consumed proportionately more ground squirrels and lagomorphs than those nesting on the control area ($P<0.01$).

On 10 survey nights between 10 May and 23 August 1990, 116 lagomorphs were counted on route surveys ($\bar{x} = 11.6$, $SD = 5.72$). A bimodal trend of lagomorph numbers was evident (Fig. 6) with peaks on 1 June and 9 August, and troughs on 18 May and 22 June. Troughs suggest multiple partuition dates of lagomorphs in the KRSA, and coincident restricted activity of females with young litters.

Of 13, 1-mile route sections on the survey route, 6 were native grass/ shrub, 2 were $\leq$17% agricultural, 1 was 25% agricultural, 3 were 50% agricultural and 1 was 100% agricultural (Table 13). Lagomorph numbers fluctuated widely both within and among land use categories (Fig. 7) and were consistently higher in survey leg 1 which passed through 3 route contiguous miles (6 linear survey miles) of primarily native grass/shrub. There, mean number of lagomorphs observed per mile was nearly 4 times greater than numbers observed in survey leg 2 which contained nearly 3.5 times less native grass/ shrub. Differences in lagomorph numbers among 5 land use categories were significant ($P<0.01$, Kruskal-Wallis Test), with numbers in native grass/ shrub significantly higher than all other categories ($P<0.05$, Scheffe Test).

Lagomorph use of some land use categories was not representative of availability. Number of rabbits was significantly higher ($P<0.01$) in 25% agricultural category and lagomorph use of 25% agricultural lands was disproportionately high compared to availability (Fig. 7). Similarly, only 6.4% of corrected numbers occurred on 50% agricultural land, which comprised

Table 9. Prey of ferruginous hawks on KRSA and control area during 1990.

Taxon	KRSA N	KRSA %	Control Area N	Control Area %
Mammals				
Ground squirrel (Spermophilus spp.)	45	71.4	10	83.3
Voles (Microtus and Lagurus spp.)	1	1.6	1	8.3
Northern pocket gopher (Thomomys talpoides)	1	1.6	0	0.0
Desert cottontail (Sylvilagus audubonii)	1	1.6	0	0.0
Total mammals	48	76.2	11	91.6
Birds				
Horned lark (Eremophila alpestris)	4	6.3	0	0.0
Vesper Sparrow (Pooecetes gramineus)	3	4.8	0	0.0
American kestrel (Falco sparverius)	2	3.2	0	0.0
Gray partridge (Perdix perdix)	1	1.6	0	0.0
Black-billed magpie (Pica pica)	1	1.6	0	0.0
Western meadowlark (Sturnella neglecta)	0	0.0	1	8.3
Unidentified passerines	3	4.8	0	0.0
Total birds	14	22.3	1	8.3
Insects				
Orthoptera	1	1.6	0	0.0
Total prey items	63		12	

Table 10. Prey of prairie falcons on KRSA and control area during 1990.

Taxon	KRSA N	KRSA %	Control area N	Control area %
Mammals				
Ground squirrel (Spermophilus spp.)	21	45.7	18	40.9
Voles (Microtus and Lagurus spp.)	6	13.0	2	4.5
Yellow-bellied marmot (Marmota flaviventris)	1	2.2	0	0.0
Northern pocket gopher (Thomomys talpoides)	1	2.2	0	0.0
Desert cottontail (Sylvilagus audubonii)	1	2.2	1	2.3
Total mammals	30	65.3	21	47.7
Birds				
Horned lark (Eremophila alpestris)	8	17.4	8	18.2
Western meadowlark (Sturnella neglecta)	2	4.3	3	6.8
Vesper sparrow (Pooecetes gramineus)	2	4.3	1	2.3
American kestrel (Falco sparverius)	0	0.0	1	2.3
Gray partridge (Perdix perdix)	0	0.0	4	9.1
McCown's longspur (Calcarius mccownii)	0	0.0	4	9.1
Unidentified ducks	2	4.3	1	2.3
Unidentified passerines	2	4.3	1	2.3
Total birds	16	34.6	23	52.4
Total prey items	46		44	

Table 11. Prey of golden eagles on KRSA and control area during 1990.

Taxon	KRSA N	KRSA %	Control Area N	Control Area %
Mammals				
Desert cottontail (*Sylvilagus audubonii*)	11	25.6	10	27.0
Ground squirrel (*Spermophilus spp.*)	10	23.3	3	8.1
Yellow-bellied marmot (*Marmota flaviventris*)	7	16.3	4	10.8
White-tailed jackrabbit (*Lepus townsendii*)	7	16.3	3	8.1
Long-tailed weasel (*Mustela frenata*)	0	0.0	1	2.7
Total mammals	35	81.5	21	56.7
Birds				
Black-billed magpie (*Pica pica*)	4	9.3	0	0.0
Gray partridge (*Perdix perdix*)	1	2.3	2	5.4
Mallard (*Anas platyrhyncos*)	0	0.0	4	10.8
Northern pintail (*Anas acuta*)	0	0.0	2	5.4
Unidentified duck	2	4.7	7	18.9
Unidentified passerine	1	2.3	0	0.0
Unidentified bird	0	0.0	1	2.7
Total birds	8	18.6	16	43.2
Total prey items	43		37	

Table 12. Prey of great horned owls on KRSA and control area during 1990.

Taxon	KRSA N	KRSA %	Control area N	Control area %
Mammals				
Deer mouse (Peromyscus maniculatus)	92	29.2	112	58.6
Voles (Microtus and Lagurus spp.)	75	23.8	42	22.0
Desert cottontail (Sylvilagus audubonii)	51	16.2	7	3.7
Northern pocket gopher (Thomomys talpoides)	28	8.9	2	1.0
Ground squirrel (Spermophilus spp.)	22	7.0	4	2.1
Bushytail woodrat (Neotoma cinerea)	8	2.5	0	0.0
White-tailed jackrabbit (Lepus townsendii)	6	1.9	4	2.1
Shrews (Sorex spp.)	2	0.6	0	0.0
Long-tailed weasel (Mustela frenata)	1	0.3	1	0.5
Yellow-bellied marmot (Marmota flaviventris)	1	0.3	0	0.0
Unidentified mammal	1	0.3	1	0.5
Total mammals	287	91.0	173	90.5
Birds				
Gray partridge (Perdix perdix)	3	1.0	2	1.0
Rock dove (Columba livia)	1	0.3	0	0.0
Western meadowlark (Strunella neglecta)	1	0.3	0	0.0
Prairie falcon (Falco mexicanus)	0	0.0	2	1.0
Unidentified passerines	23	7.3	14	7.3
Total birds	28	8.9	18	9.3
Total prey items	315		191	

Table 13. Mean number of lagomorphs and percent agriculture per mile section of survey route on the KRSA during 1990.

Survey Leg 1			Survey Leg 2		
Mile	% Agriculture[a]	Mean # Rabbits[a]	Mile	% Agriculture	Mean # Rabbits[a]
1	0	1.3	1	0	0.6
2	0	3.1	2	17	0.5
3	25	1.9	3	17	1.0
			4	0	1.2
			5	0	0.6
			6	50	0.0
			7	50	0.1
			8	100	0.0
			9	50	0.7
			10	0	0.6
Total/Leg					
3	8.3	2.1	10	28.4	0.5

[a]Per linear unit route distance.

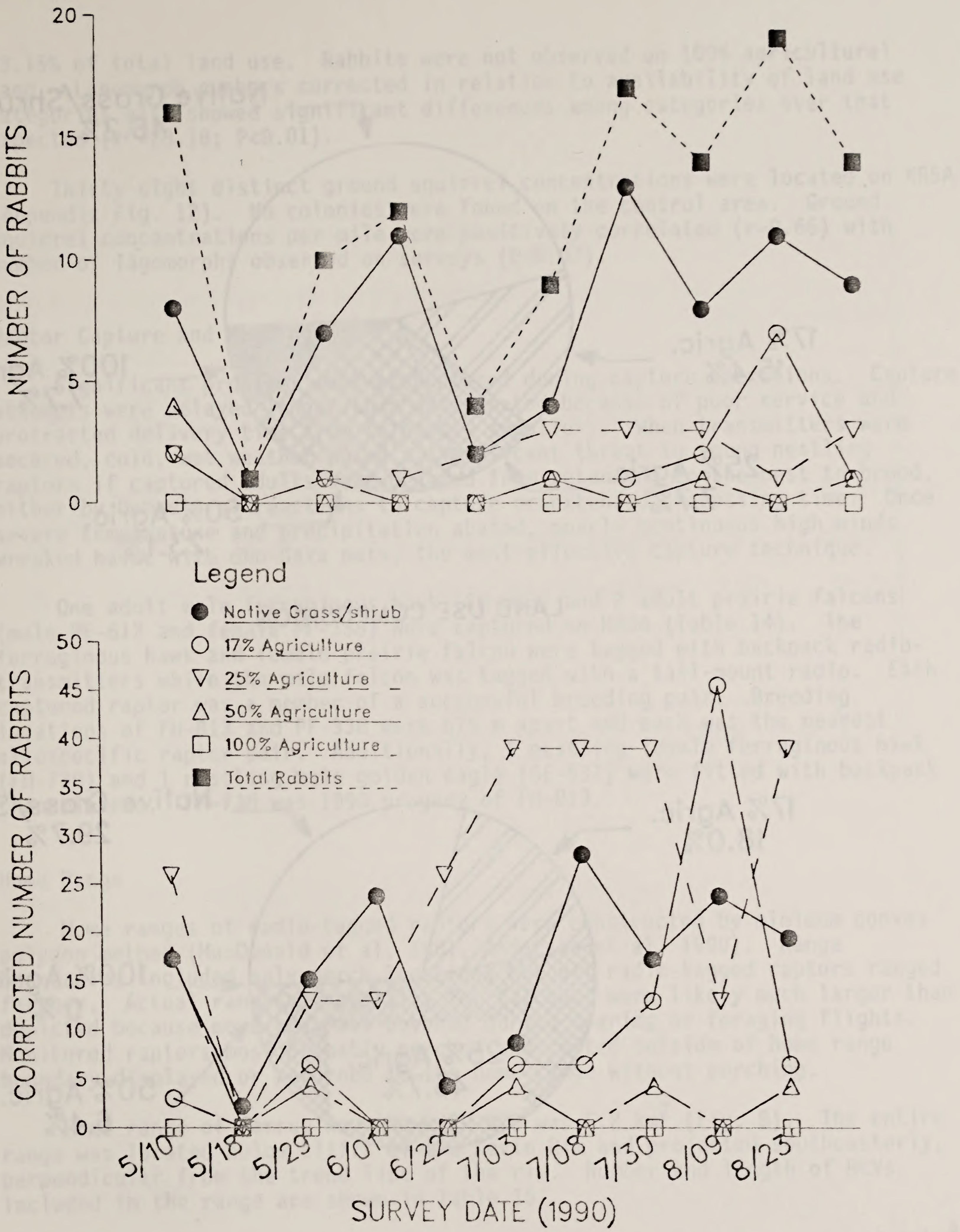
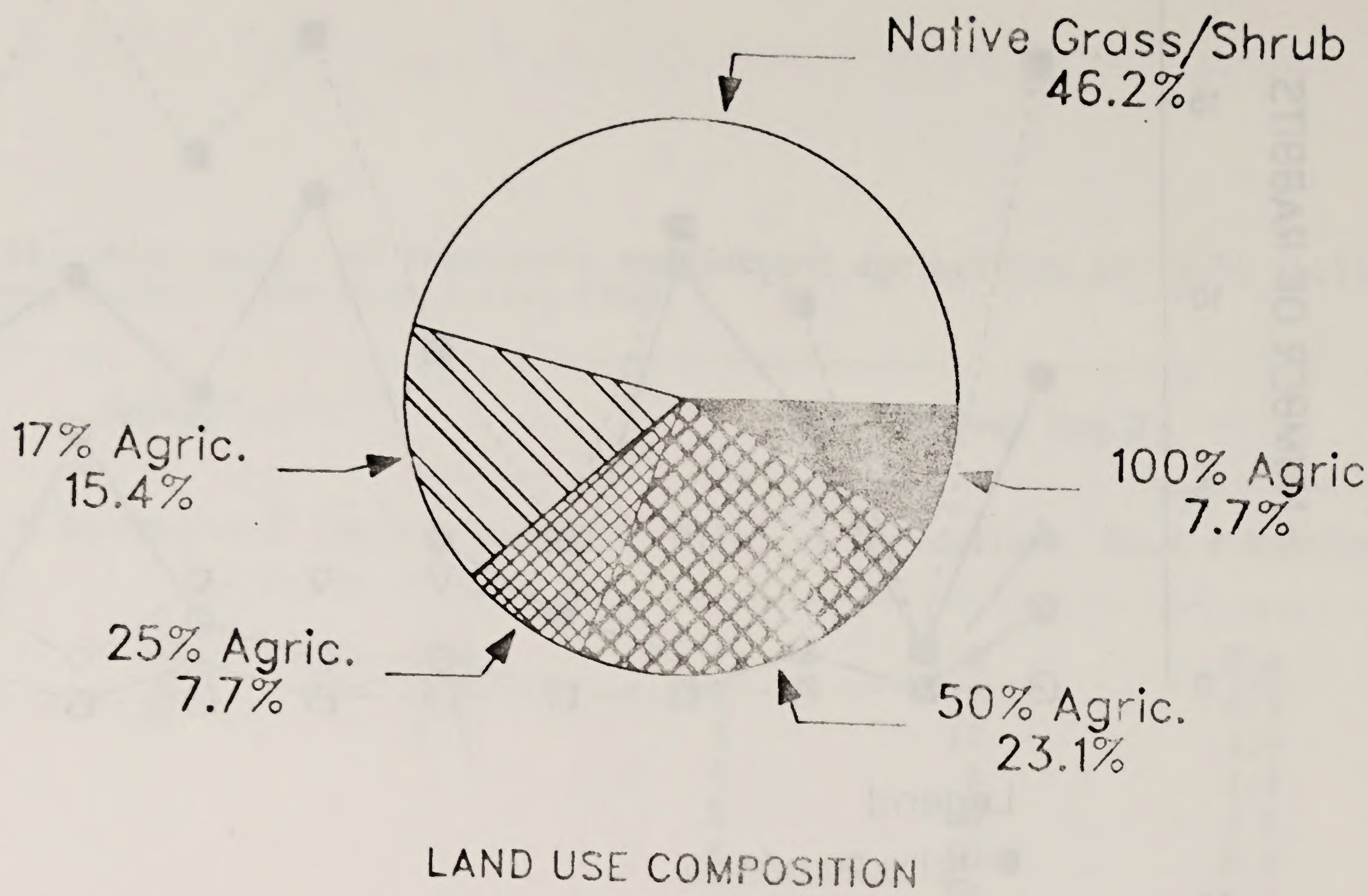


Figure 6. Absolute number of rabbits counted per survey date per land use category (top) and number of rabbits corrected for availability of land use categories (bottom).



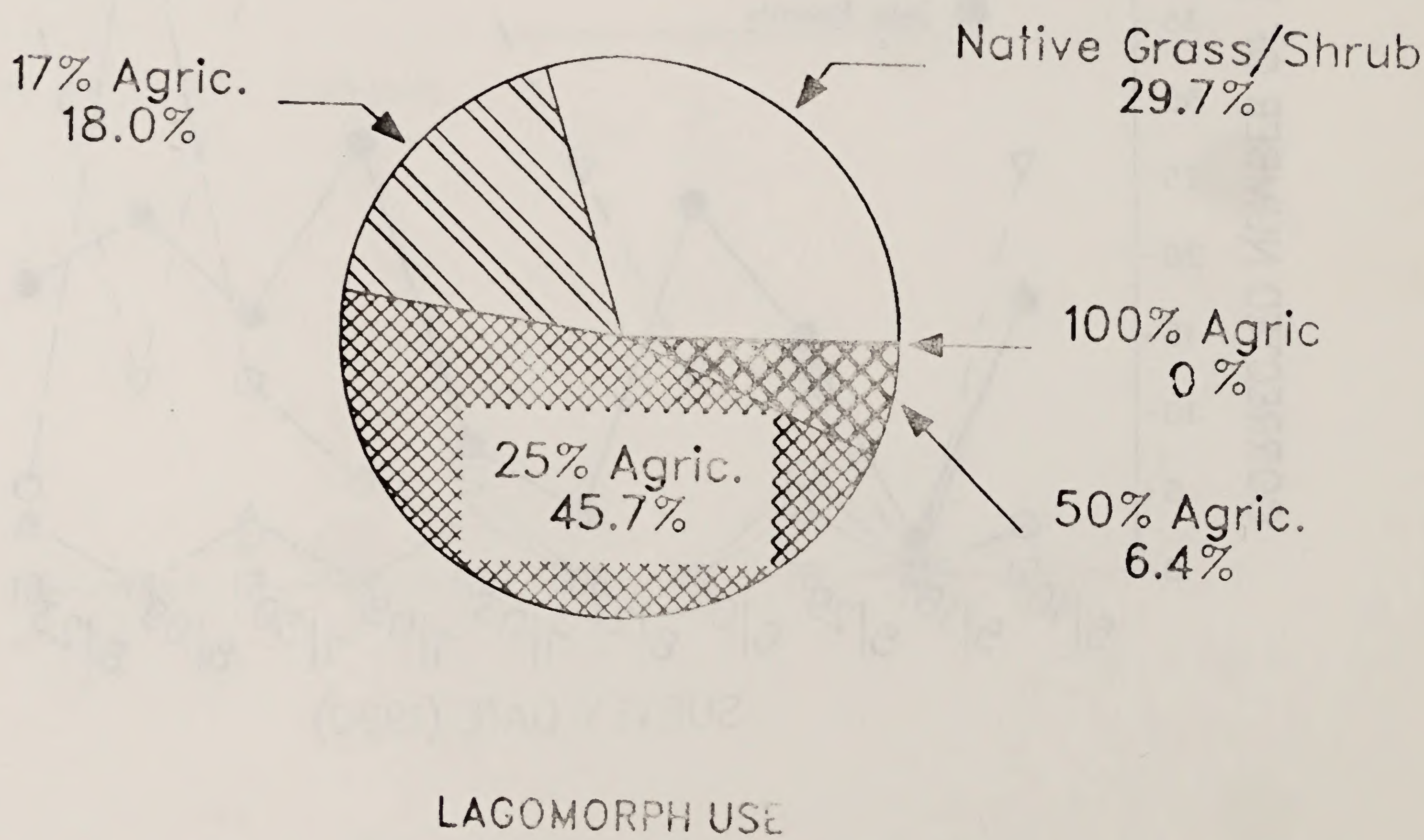


Figure 7. Land use composition (top) and respective proportional use by rabbits (bottom) of lagomorph survey route miles in KRSA, 1990.

23.15% of total land use. Rabbits were not observed on 100% agricultural land. Lagomorph numbers corrected in relation to availability of land use categories also showed significant differences among categories over that expected (X^2=28.18; P<0.01).

Thirty-eight distinct ground squirrel concentrations were located on KRSA (Appendix Fig. 12). No colonies were found on the control area. Ground squirrel concentrations per mile were positively correlated (r=0.66) with number of lagomorphs observed on surveys (P=0.07).

Raptor Capture and Marking

Significant problems were encountered during capture operations. Capture attempts were delayed longer than anticipated because of poor service and protracted delivery time from telemetry suppliers. When transmitters were secured, cold, wet weather posed a significant threat to young nestling raptors if captured adults were delayed from returning to the nest to brood, either by behavioral reactions to capture or extended processing time. Once severe temperature and precipitation abated, nearly continuous high winds wreaked havoc with dho-Gaza nets, the most effective capture technique.

One adult male ferruginous hawk (FH-813) and 2 adult prairie falcons (male PF-612 and female PF-338) were captured on KRSA (Table 14). The ferruginous hawk and female prairie falcon were tagged with backpack radio-transmitters while the male falcon was tagged with a tail-mount radio. Each captured raptor was a member of a successful breeding pair. Breeding locations of FH-813 and PF-338 were 675 m apart and each was the nearest allospecific raptor pair. Additionally, 1 nestling female ferruginous hawk (FH-738) and 1 nestling male golden eagle (GE-537) were fitted with backpack transmitters. FH-738 was 1990 progeny of FH-813.

Home Range

Home ranges of radio-tagged raptors were constructed by minimum convex polygon method (MacDonald et al. 1981, Anderson et al. 1990). Range boundaries included only perch locations but all radio-tagged raptors ranged farther. Actual ranges, especially for falcons, were likely much larger than depicted because more area was covered during soaring or foraging flights. Monitored raptors most probably perched undetected outside of home range boundary displayed or returned to the home range without perching.

Home range of ferruginous hawk FH-813 was 6.2 km^2 (Fig. 8). The entire range was located below cliffs of the Kevin Rim and projected southeasterly, perpendicular from the trend line of the rim. Number and length of HCVs included in the range are shown in Table 15.

Home ranges of radio-tagged male and female prairie falcons were 8.1 km^2 and 10.1 km^2, respectively (Fig. 9). Like the radio-tagged ferruginous hawk, range of the adult female prairie falcon PF-338 projected southeasterly away from the rim. Unlike the hawk, the falcon's range included area above the rim, probably much more than indicated because she was out of visual and telemetry range for long periods after disappearing over the rim. Ranges of the female falcon and ferruginous hawk included 3.9 km^2 of common area.

Table 14. Capture results and monitoring time for raptors radio-tagged on KRSA during 1990.

Date of Capture	Time of Capture	Raptor Species	Capture Method	Inclusive Dates of Monitoring	Hours Monitored
6/19/90	0930	Prairie falcon	dho-gaza	6/19/90 - 6/28/90	6.25
6/23/90	1135	Ferruginous hawk	dho-gaza	6/23/90 - 8/22/90	93.25
7/9/90	1015	Prairie falcon	dho-gaza	7/9/90 - 8/10/90	28.50

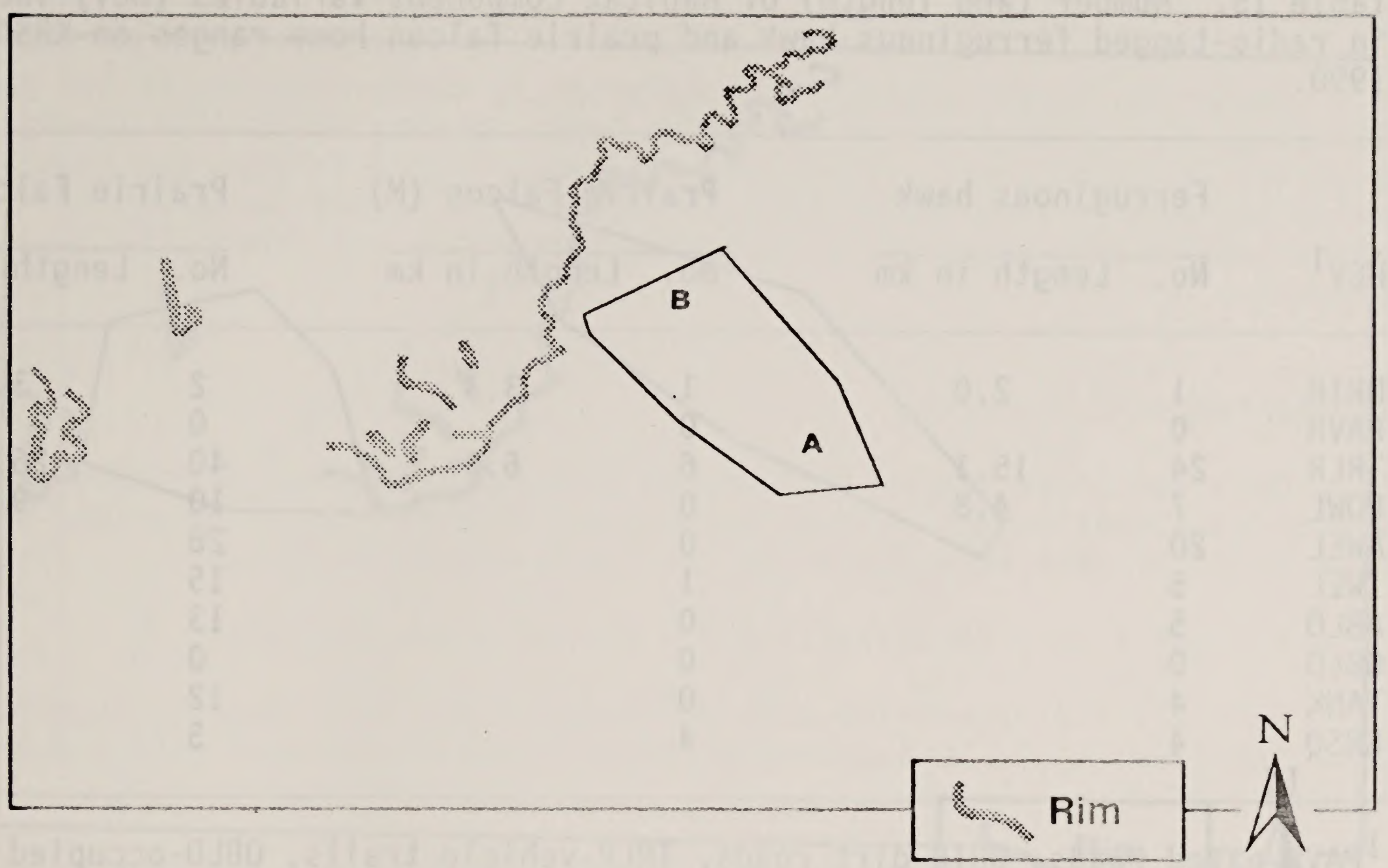


Figure 8. Home range polygon of radio-tagged adult male ferruginous hawk FH-813, KRSA, June-August 1990. Area A was primary foraging area of both FH-813 and PF-338. Area B was also used by falcons for foraging.

Table 15. Number (and length) of Habitat Component Variables (HCV) included in radio-tagged ferruginous hawk and prairie falcon home ranges on KRSA during 1990.

	Ferruginous hawk		Prairie Falcon (M)		Prairie Falcon (F)	
HCV[1]	No.	Length in km	No.	Length in km	No.	Length in km
DRTR	1	2.0	1	3.3	2	3.6
PAVR	0		0		0	
TRLR	24	15.1	6	6.0	40	26.4
POWL	7	4.8	0		10	9.5
AWEL	20		0		28	
IWEL	5		1		15	
ABLD	5		0		13	
OBLD	0		0		0	
TANK	4		0		12	
GRSQ	4		4		5	

[1]PAVR-paved roads, DRTR-dirt roads, TRLR-vehicle trails, OBLD-occupied buildings, ABLD-abandoned buildings, AWEL-active oil/gaswell, IWEL-inactive oil/gas well, TANK-oil storage tank, POWL-powerlines, GRSQ-ground squirrel concentrations, KRIM-summit of Kevin Rim.

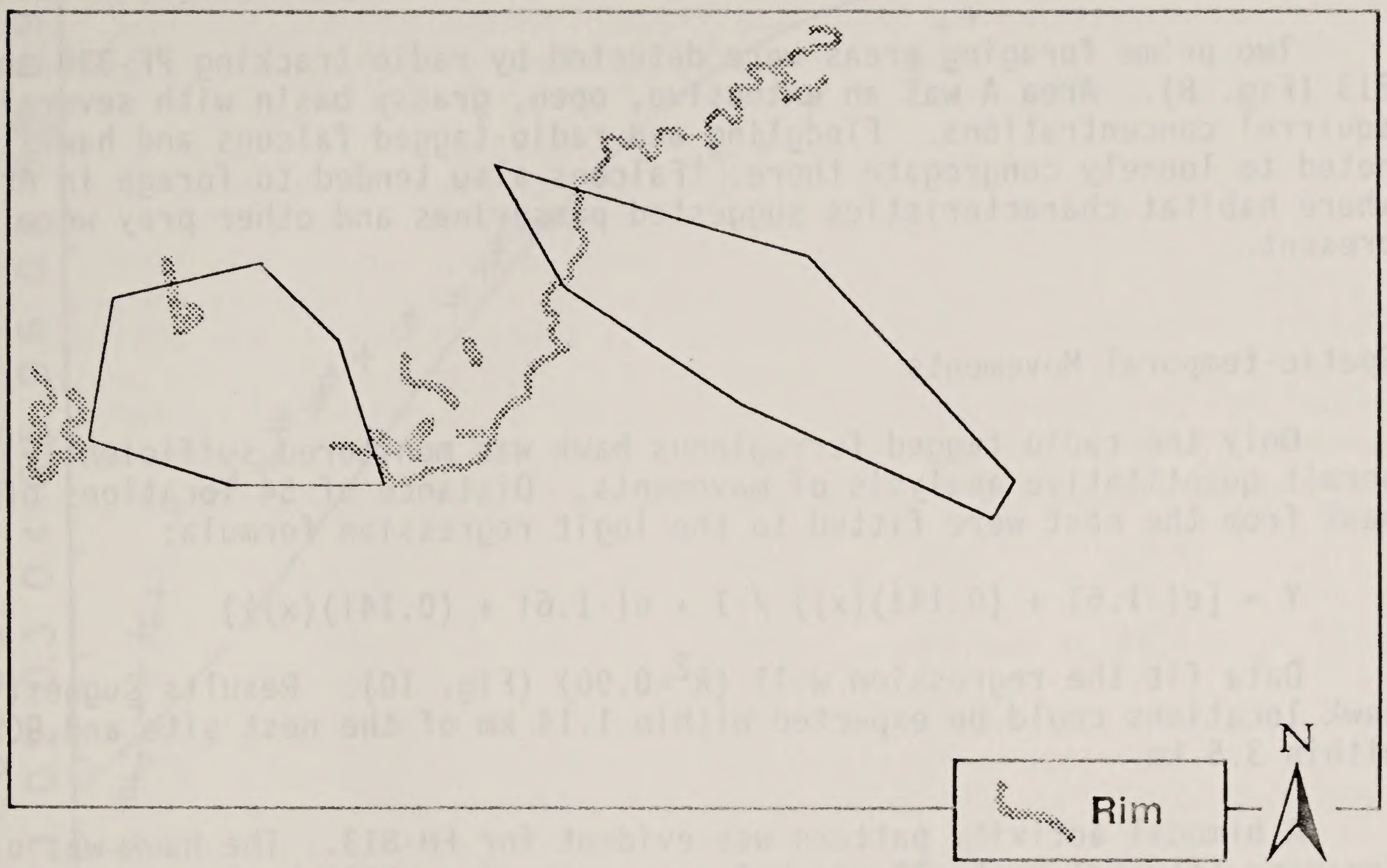


Figure 9. Home range polygons of radio-tagged adult male prairie falcon PF-612 (left) and adult female prairie falcon PF-338 in KRSA, spring-summer 1990.

Range of the male prairie falcon PF-612 was less linear than the female's but difficulty in tracking probably biased home range size and shape. The male falcon was out of visual and telemetry perception for long periods and may have been much farther away from the eyrie than range size and shape indicate. Amount of HCVs included in falcon home ranges are shown in Table 15. Home ranges of the juvenile ferruginous hawk and golden eagle were not constructed due to lack of monitoring time and paucity of precise locations.

Two prime foraging areas were detected by radio-tracking PF-338 and FH-813 (Fig. 8). Area A was an extensive, open, grassy basin with several ground squirrel concentrations. Fledgling and radio-tagged falcons and hawks were noted to loosely congregate there. Falcons also tended to forage in Area B where habitat characteristics suggested passerines and other prey were present.

Spatio-temporal Movements

Only the radio-tagged ferruginous hawk was monitored sufficiently to permit quantitative analysis of movements. Distance of 54 locations of the hawk from the nest were fitted to the logit regression formula:

$$Y = [e(-1.61 + (0.141)(x)) / 1 + e(-1.61 + (0.141)(x))]$$

Data fit the regression well (R^2=0.90) (Fig. 10). Results suggest 50% of hawk locations could be expected within 1.14 km of the nest site and 90% within 3.5 km.

A bimodal activity pattern was evident for FH-813. The hawk was often foraging (flying) up to 30 min before sunrise (ca. 0530 hrs) but seemed to restrict early morning movements to within a few hundred meters of the nest. At about 0930 hrs, he would often fly to an obviously preferred foraging area in the southeastern portion of the home range (Fig. 8). Between 1430 and 1500 he would usually return to the nest area until about 1630 to 1700 hrs, then return to foraging areas away from the nest until about 2000 hrs. By about 11 August an obvious change in foraging habits was noticed. FH-813 ranged farther (i.e. covered more area within the home range) and tended not to return to the nest site.

PF-338 tended to hunt far from the eyrie in early and late morning. During mid-morning and mid-afternoon, activity was divided between foraging areas up to 2 km from the eyrie, above and below the rim. During late afternoon and evening, the falcon tended to be associated with the eyrie but also often flew above and away from the rim. Subsequent to 10 August, PF-338 was not detected, although searched for until 23 August. Absence of a signal and diminished sightings of falcons overall suggested she dispersed from the vicinity of KRSA in mid August.

PF-612 shed his tail-mounted transmitter after only 6.25 hrs of monitoring over 9 days. Paucity of visual locations and rapidity of movement prevented adequate assessment of activity patterns, but the male falcon appeared to be active earlier and away from the eyrie longer than the female falcon.

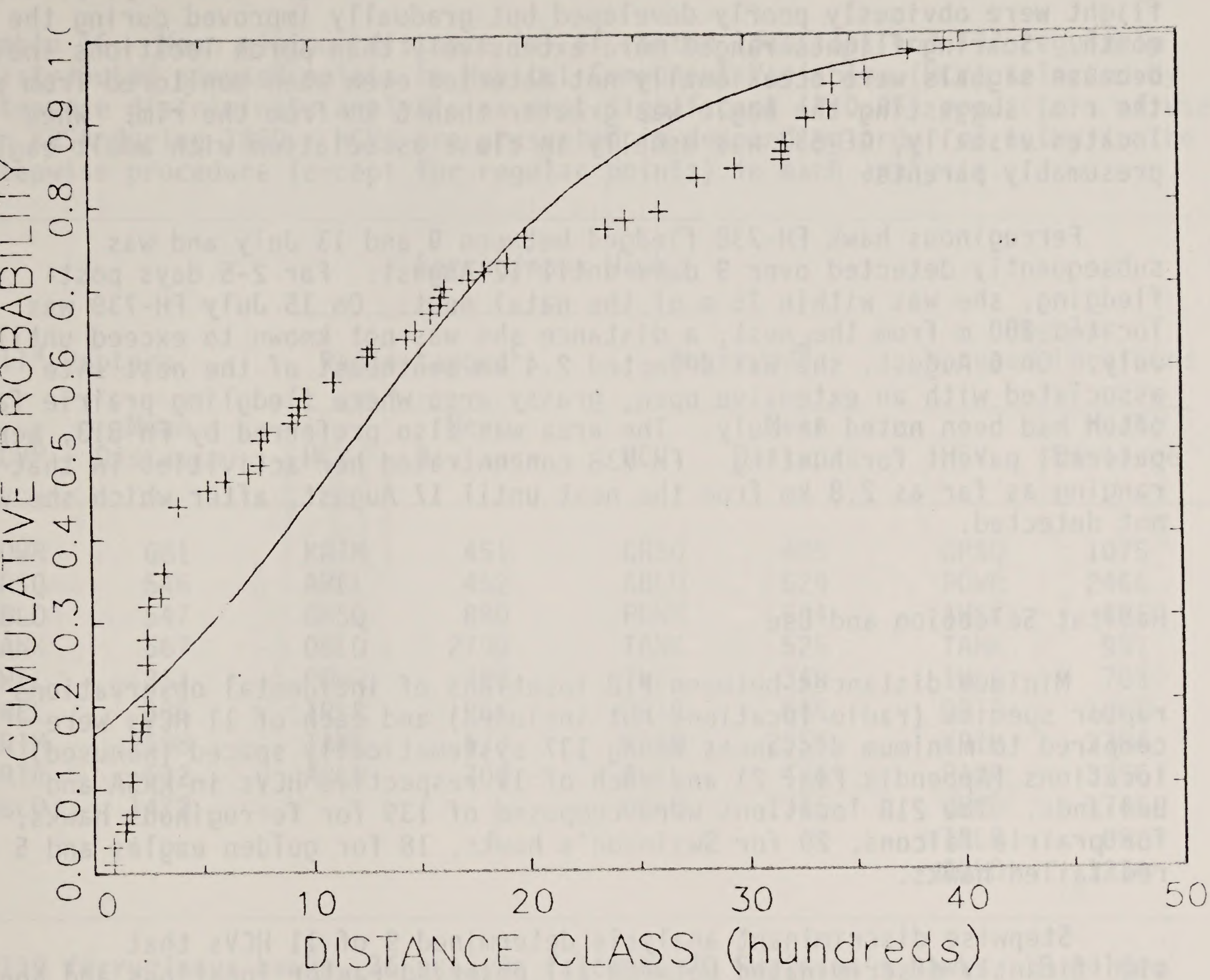


Figure 10. Logit regression curve of cumulative percent of perches by distance class from the nest for radio-tagged ferruginous hawk FH-813. Approximately 50% of all perches were within 1500 meters from the active nest.

Golden eagle GE-537 fledged on 4 July and was subsequently detected over 31 days to 23 August when tracking ceased. Throughout that period, the eagle was not located perched farther than 1 km from his natal nest and usually on or below the cliffs of Kevin Rim. First noted soaring on 21 July, powers of flight were obviously poorly developed but gradually improved during the next month. Soaring flights ranged more extensively than perch locations indicate because signals were occasionally not detected even when monitored from atop the rim, suggesting the eagle was greater than 5 km from the rim. When located visually, GE-537 was usually in close association with adult eagles, presumably parents.

Ferruginous hawk FH-738 fledged between 9 and 13 July and was subsequently detected over 9 days until 17 August. For 2-5 days post-fledging, she was within 75 m of the natal nest. On 15 July FH-738 was located 200 m from the nest, a distance she was not known to exceed until 31 July. On 6 August, she was detected 2.4 km southeast of the nest site associated with an extensive open, grassy area where fledgling prairie falcons often had been noted in July. The area was also preferred by FH-813, her paternal parent for hunting. FH-738 concentrated her activities in that area ranging as far as 2.8 km from the nest until 17 August, after which she was not detected.

Habitat Selection and Use

Minimum distances between 218 locations of incidental observations of 5 raptor species (radio locations not included) and each of 11 HCVs were compared to minimum distances among 137 systematically spaced (nonused) locations (Appendix Fig. 2) and each of 11 respective HCVs in KRSA and Badlands. The 218 locations were composed of 139 for ferruginous hawks, 36 for prairie falcons, 20 for Swainson's hawks, 18 for golden eagles and 5 for red-tailed hawks.

Stepwise discriminant analysis determined 9 of 11 HCVs that significantly discriminated between all observed raptor locations and nonused locations (Table 16). Reclassification of observed and nonused locations by discriminant function using coefficients of the HCVs resulted in 94.4% total correct classification (98.2% observed, 86.9% nonused classified correctly) with observed and nonused cases clumping by discriminant score (Fig. 11). The data fit the resultant linear function well (canonical correlation=0.843) which suggests strong selection for (or avoidance of) habitat components. Use of a specific location by any of 5 raptor species in the KRSA may be predicted by inserting raw distance of each observation (used) from respective 9 HCVs with respective coefficient values into equations:

$$R_{use} = X_{1u}\ (HCV_1) + X_{2v}\ (HCV_2)\ \ldots\ldots\ X_{9u}\ (HCV_9) + K_u$$

$$R_{nonuse} = X_{1e}\ (HCV_1) + X_{2e}\ (HCV_2)\ \ldots\ldots\ X_{9e}\ (HCV_9) + K_e,$$

where: X_{nu} = used coefficient value for HCV_n (i.e. POWR),

X_{ne} = nonused coefficient value for HCV_n,

Table 16. Mean minimum distance (m) of raptor locations and 137 regularly distributed nonused points to Habitat Component Variables (HCV) selected by stepwise discriminate analysis as most significant (P<0.05) predictors of use on KRSA during 1990. HCVs are presented in descending order of entry in the stepwise procedure (except for regular points) in each analysis.

All[a] Raptors		Ferruginous Hawk: Radio-tagged[c]		Ferruginous Hawk: Observed[d]		Regular Nonused Locations	
HCV[b]	Mean Distance	HCV	Mean Distance	HCV	Mean Distance	HCV	Mean Distance
POWR	681	KRIM	451	GRSQ	485	GRSQ	1075
GRSQ	546	AWEL	452	ABLD	629	POWR	2466
ABLD	547	GRSQ	880	POWR	644	AWEL	685
TANK	567	OBLD	2790	TANK	525	TANK	991
AWEL	351	POWR	788	IWEL	349	IWEL	703
IWEL	388	TRLR	261	DRTR	646	DRTR	1066
KRIM	2598	TANK	673	KRIM	2555	KRIM	3384
DRTR	632	ABLD	700	AWEL	476	PAVR	5556
OBLD	1472			OBLD	1345	OBLD	1745
						TRLR	822
						ABLD	1234

[a]139 ferruginous hawks, 36 prairie falcons, 20 Swainson's hawks, 18 golden eagles, 5 red-tailed hawks.

[b]PAVR-paved roads, DRTR-dirt roads, TRLR-vehicle trails, OBLD-occupied buildings, ABLD-abandoned buildings, AWEL-active oil/gaswell, IWEL-inactive oil/gas well, TANK-oil storage tank, POWL-powerlines, GRSQ-ground squirrel concentrations, KRIM-summit of Kevin Rim.

[c]N=87 weighted (see text) locations.

[d]N=139.

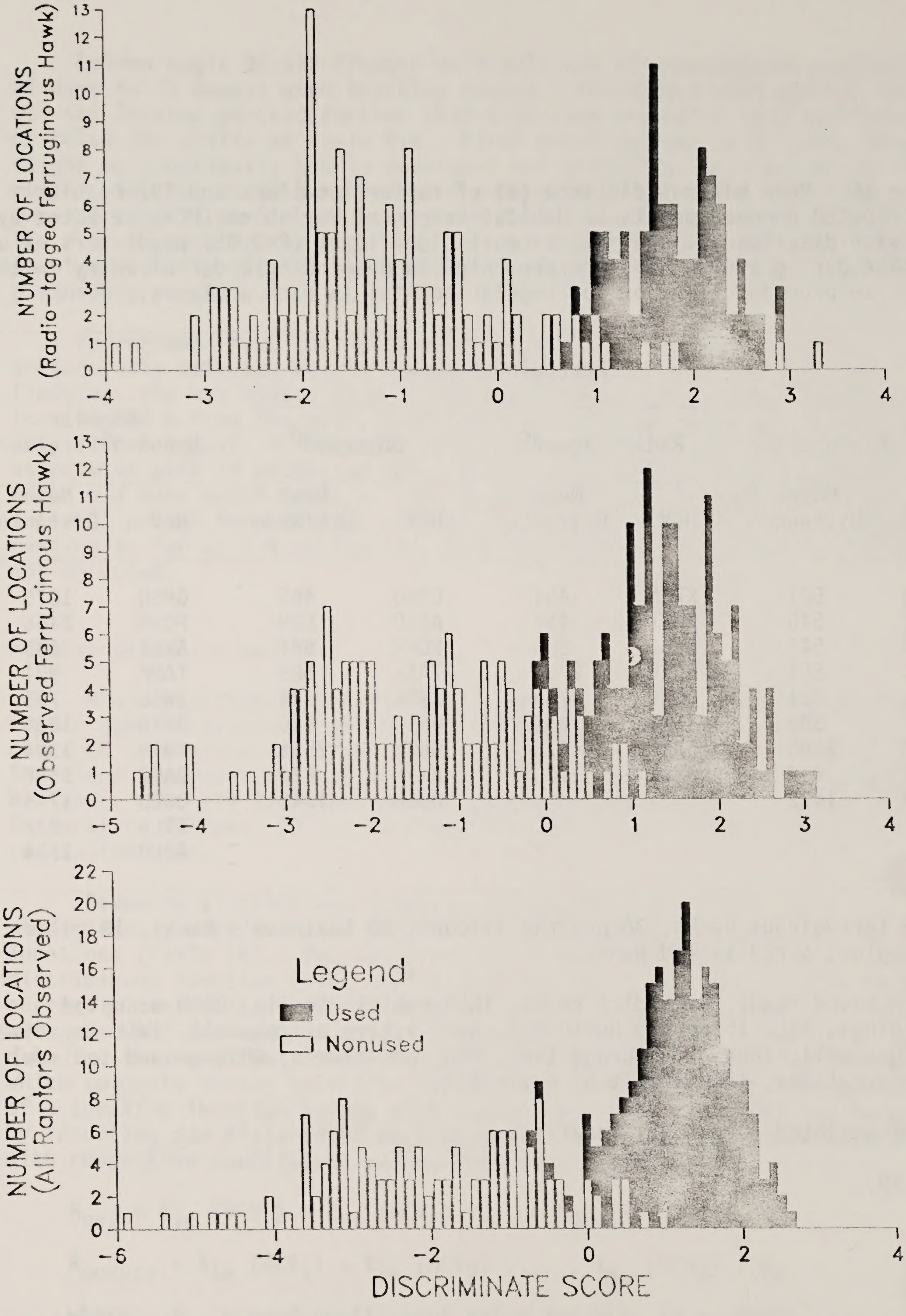


Figure 11. Frequency histograms of raptor locations and nonused locations by discriminant score.

HCV_n = distance (m) of observed location from HCV (i.e. POWL),

K_u = constant for used function,

K_e = constant for nonused function.

If $R_{use} > R_{nonuse}$ the location may likely be used by raptors.

If $R_{use} < R_{nonuse}$ the location will not likely be used.

Analysis of mean minimum distance of 87 weighted locations of radio-tagged ferruginous hawk FH-813 from 11 HCVs revealed 8 HCVs which discriminated significantly between used and nonused locations (Table 16). Reclassification of used and nonused locations by discriminant function resulted in 92% total correct classification (100% used and 88% nonused classified correctly). Distribution of cases by discriminant score showed used and nonused locations fairly compactly clumped with centroids widely separated (Fig. 11). Canonical correlation was 0.824. Use of a specific location in KRSA and Badlands by the radio-tagged ferruginous hawk may be predicted by employing classification function equation, above. Coefficients and constants for predictive equations are shown in Table 17.

Analysis of mean minimum distances of 139 incidental ferruginous hawk locations from 11 HCVs revealed 9 HCVs that discriminated significantly between used and nonused locations. Reclassification of locations by discriminant function resulted in 91.7% total correct classification (98.6% used and 86.9% nonused correctly classified). Canonical correlation was 0.831. Again, distribution of both used and nonused locations were clumped with centroids separated (Fig. 11). Use of a specific location away from a nest site may be predicted for a ferruginous hawk on the KRSA by employing the above classification functions. Coefficients and constants for use in predictive equations are shown in Table 17.

Raptor Mortalities

Approximately 33 km of powerlines in KRSA were surveyed for dead raptors. Surveys were conducted on 8 days between 11 May and 8 August. Four raptors were found dead below powerlines (Table 18), 3 exhibiting singed feathers indicating electrocution. All had been dead at least 1 month, eagles more than 3 months. One golden eagle was banded as a nestling in 1989 and was found below a powerpole 3.6 km from its natal nest. Its tail feathers had been removed. Both eagles recovered were found below polelines traversing hills overlooking ground squirrel concentrations in areas of high lagomorph numbers (east 1/2, section 28 T35N, R3W). The recovered owl was obviously a recently fledged bird when killed because primary feathers were in the development stage (blood quills).

Three fledgling prairie falcons were found dead. One was definitely preyed upon by a great horned owl, another either by an owl or golden eagle and both within a few meters of the nest in July. One falcon was recovered below a powerpole with a transformer, 196 km north near Bassano Alberta on 24 October 1990. The falcon was definitley elctrocuted because the person who encountered the band indicated she was found immediately after a breaker switch on that pole had been tipped.

Table 17. Habitat Component Variables (HCV) and respective classification function coefficients ($\times 10^{-3}$) and constants ($\times 10^{-3}$) for observed (used) and nonused locations of raptors on the KRSA during 1990.

	All Raptors[a]		Ferruginous Hawk					
			Radio-tagged			Observed		
	Coefficient			Coefficient			Coefficient	
HCV[b]	Used	Nonused	HCV	Used	Nonused	HCV	Used	Nonused
POWR	-0.06	0.75	KRIM	0.77	2.27	GRSQ	4.30	8.46
GRSQ	5.04	9.36	AWEL	4.46	8.06	ABLD	1.54	3.13
ABLD	2.18	4.33	GRSQ	5.55	7.76	POWR	-0.15	0.53
TANK	3.79	6.62	OBLD	3.17	1.96	TANK	2.82	5.43
AWEL	5.46	10.40	POWR	-0.08	1.44	IWEL	5.32	9.33
IWEL	5.82	9.75	TRLR	0.17	-2.98	DRTR	2.24	3.61
KRIM	1.28	1.82	TANK	2.80	4.40	KRIM	1.09	1.58
DRTR	2.34	3.50	ABLD	2.17	3.19	AWEL	3.76	5.39
OBLD	2.69	3.21				OBLD	2.08	2.64
Constant:								
	-10240.9	-27342.2		-10422.4	-17882.3		-8256.4	-22543.5

[a] 218 incidental locations

[b] PAVR-paved roads, DRTR-dirt roads, TRLR-vehicle trails, OBLD-occupied buildings, ABLD-abandoned buildings, AWEL-active oil/gaswell, IWEL-inactive oil/gas well, TANK-oil storage tank, POWL-powerlines, GRSQ-ground squirrel concentrations, KRIM-summit of Kevin Rim.

Table 18. Raptors recovered below powerpoles on KRSA, 1990.

Species	Date Found	Maximum Age (At Death)	Distance From Conspecific Nest
Golden Eagle	5/11	less than 1 yr.	3.6 km[1]
Golden Eagle	5/11	less than 1 yr.	3.6 km
Great Horned Owl	7/23	fledgling	6.0 km
Unidentified Buteo	5/24	Immature	3.7 km

[1]Natal Nest, eagle banded as nestling 1989.

Egg shell fragments were found in 1 ferruginous hawk nest that failed. Proximity of the nest to a riparian area (corvid, mustelid and carnivore habitat), a great horned owl eyrie and a golden eagle nest suggest predation on eggs, nestlings or adults, rather than impacts of weather and subsequent destruction of an addled egg.

Contaminants

Heavy metal residues in blood of raptors in KRSA and control area are shown in Table 19. No blood samples from golden eagle nestlings in the control area were obtained and a sample from a golden eagle nestling in KRSA was lost during analysis for heavy metals. Analysis of the golden eagle blood for organochlorines showed none detected. No samples were taken from great horned owls or kestrels, and 2 Swainson's hawk samples were not analyzed.

Mean heavy metal residues in blood of all ferruginous hawks were 0.39, 0.59, and 0.02 ppm for Pb, Se, and Hg, respectively. Pb was detected in 37.5% of ferruginous hawks tested, Se in 100%, and Hg in only 12.5%. In hawks in which metals were detected, mean levels were 0.62, 0.59 and 0.13, for Pb, Se and Hg, respectively.

Mean ppm residues of Pb, Se, and Hg in prairie falcons were 0.07, 0.84, and 0.0, respectively. Incidence of Pb, Se, and Hg detected in falcons was 45.5%, 90.0%, and 0%, respectively. Mean detected levels in falcons were 0.16, 0.92 and 0.0 for Pb, Se and Hg, respectively.

Heavy metal residues were not significantly different statistically between ferruginous hawks and prairie falcons. However, biological significance may be indicated (P=0.20) in Pb residues. Ferruginous hawk nestlings had both higher incidence (57.1%) and mean level (0.71 ppm) for Pb in those than prairie falcons (44.4% and 0.15 ppm). For Se, incidence was the same for nestling ferruginous hawks and prairie falcons (100%), but mean level for hawks was lower (0.52 ppm) than for falcons (0.96).

Sample sizes were too small to compare heavy metal levels among nestling ferruginous hawks or prairie falcons in KRSA and control area. Regardless, Pb levels in ferruginous hawks were higher in KRSA than control but Se levels were lower in KRSA than control. The only raptor that exhibited a detectable level of Hg was a nestling ferruginous hawk in the control area.

Results of analyses of dry fixed smears for hematozoa were not available as of this writing. They will be submitted as an addendum when obtained.

Table 19. Contaminant levels (ppm wet) in adult (AD) and nestling (HY) ferruginous hawks and prairie falcons on KRSA and Control Area during 1990.

Area, Species and Territory Number	Age	Sex	Lead	Selenium	Mercury
KRSA					
Ferruginous - 1	HY[a]	F	0.14	0.32	N.D.[b]
Ferruginous - 2	HY	M	N.D.	0.65	N.D.
Ferruginous - 6	HY	F	1.40	0.53	N.D.
Ferruginous - 6	AD[c]	M	0.28	1.10	N.D.
Ferruginous - 7	HY	F	N.D.	0.81	N.D.
Ferruginous - 9	HY	F	0.20	0.34	N.D.
Prairie - 8	HY	F	0.16	0.23	N.D.
Prairie - 8	AD[c]	F	0.17	0.59	N.D.
Prairie - 12	HY	F	0.12	2.00	N.D.
Prairie - 12	AD[c]	M	N.D.	N.D.	N.D.
Prairie - 13	HY	M	N.D.	0.37	N.D.
Control					
Ferruginous - 29	HY	M	1.10	0.52	0.13
Ferruginous - 30	HY	M	N.D.	0.48	N.D.
Prairie - 24	HY	F	N.D.	0.79	N.D.
Prairie - 25	HY	F	N.D.	0.62	N.D.
Prairie - 27	HY	F	0.15	1.60	N.D.
Prairie - 28	HY	F	0.18	1.50	N.D.
Prairie - 34	HY	F	N.D.	0.93	N.D.
Prairie - 36	HY	F	N.D.	0.56	N.D.
Method detection limits:			0.10	0.20	0.10

[a]Hatch year aged bird, nestling.

[b]None detected.

[c]Radio-tagged.

DISCUSSION

Effects of Physical and Biological Differences Between Study Areas

Significant differences existed in habitat quality and quantity between KRSA and control. Differences were manifested in raptor nesting density, productivity, and prey availability as reflected in food habits of nesting raptors. Nesting habitat for all species analyzed appeared more suitable in KRSA than control. Differences were primarily a function of physical structure of cliffs, vegetative composition and amount of agriculture in each area because oil and gas development activity was virtually absent in control. Structural suitability of habitat for nesting was greater in KRSA than controls as reflected by close proximity of adjacent pairs of nesting raptors, greater substrate and nest heights and higher nesting density in KRSA. Nesting habitat in KRSA allowed greater densities and proximities of nesting raptors because cliff lines were more involuted per linear unit than control and faced away from the acute angle of the rim line. Cliff structure allowed raptor nest sites to be closer in KRSA by visually insulating adjacent sites from each other, thereby minimizing inter- and intraspecific territoriality and strife. Nests situated on higher cliffs promoted increased security. Cliff lines in control areas had less involutions per linear distance of rim, were parallel and faced each other (e.g. Buckley Coulee) and nest heights (i.e. cliff heights) were lower.

Home ranges of FH-813 and PF-338 were elongated and radiated nearly perpendicularly from the trend line of Kevin Rim. Although only 3 raptors nesting along the main rim were radio-tagged, home range configurations were consistent with those detected along the Snake River Canyon, ID--another area of high raptor nesting density (Dunstan et al. 1978, USDI 1989). Compressed shape of ranges is probably indicative of high nesting density and suggests KRSA may approach maximum raptor nesting density in available habitat.

Nest Site Selection in KRSA

Ferruginous hawk nests were closer to occupied buildings than 25 points systematically located along the rim in KRSA. Differences in mean distances from occupied buildings may have been an artifact of random point placement (rim top) or paucity of occupied buildings outside of the town of Kevin or both. Only 5 occupied buildings were outside Kevin in KRSA (Appendix Fig. 10). Mean distance to occupied buildings for occupied nests was almost half that of systematic points but was nearly 1/3 km. Only 1 occupied ferruginous hawk nest and 1 systematic point were within 2000 m of an occupied building. The occupied building closest to the rim was in the southern portion of KRSA. Many occupied nests were located along the southern and southeastern portion of the rim (Fig. 2) while systematic locations were more evenly distributed along the length of the rim in KRSA.

Most prairie falcon eyries were clustered along the south facing cliffs in the southern portion of KRSA (Fig. 3). Ground squirrel concentrations were distributed primarily in the southern-southeastern portion of KRSA (Appendix Fig. 12) as was the only paved road within 5 km of the rim. One of only 5 occupied buildings outside of the town of Kevin also was located in the southern portion of K··SA.

Raptor Productivity - Prey Relationships

Productivity appeared a function of availability and type of prey as reflected in raptor food habits and proximity to prey concentrations. Productivity of buteos was higher in KRSA than control, while opposite was true for falcons and owls. Buteos, specifically ferruginous hawks, are mammalian specialists (Schmutz 1984). No ground squirrel concentrations were obvious in controls, but 38 concentrations were noted in KRSA. Ferruginous hawks ate a greater percentage of ground squirrels in control areas than KRSA, but fewer hawk pairs were present and they were less productive. Higher density of ground squirrels in KRSA probably increased availability, hence greater density and productivity of buteos. Productivity of ferruginous hawks within the KRSA was higher the closer nests were to ground squirrel concentrations.

Being exclusively diurnal, ground squirrels are less available to owls than more crepuscular or nocturnal mammals. Prairie falcons prey more on birds than buteos. More large lakes and intermittent ponds were within 5 km of raptor breeding sites in control than KRSA, providing more proximate habitat for waterfowl and wading birds. Also, a much larger percentage of control area, specifically Buckley Coulee vicinity, was devoted to agriculture than KRSA. Although not quantified, extensive areas of monoculture were obviously present, especially land above rim rock. Game birds and upland passerines are attracted to agricultural areas and were probably more abundant (or available) in control than KRSA. Both lakes and agriculture probably influenced diversity, abundance and availability of prey biomass; reduced for mammals and increased for birds. Prey remains of falcons and owls may have represented proportional availability. Birds provide much higher energy per unit biomass than mammals (Stahlmaster and Gessamen 1984) and greater number of high-energy foods probably result in higher productivity, i.e., of falcons and owls in control over KRSA.

Although prairie falcon productivity was higher in control than KRSA, absolute number of young produced per linear unit of nesting habitat was less (0.53 control; 0.8 KRSA). Absolute great horned owl productivity was higher in control than KRSA (0.16 control vs. 0.11 KRSA), possibly related to increased numbers of microtines associated with agriculture.

Lagomorphs are primary prey of many North American raptors (e.g. Brown and Amadon 1968). Lagomorphs were important prey for hawks, falcons, eagles and owls in both control and KRSA (Tables 9-12). Results of surveys on KRSA showed a positive effect of low percent agricultural development on rabbits but may be somewhat misleading. Distribution of agriculture in relation to native grass/shrub habitat was more influential than absolute percent of agricultural development. Highest absolute lagomorph numbers were recorded in route miles of contiguous native habitat and highest corrected numbers of lagomorphs were recorded in single route miles of 25% agriculture that were interspersed among native habitat route miles. However, as number of contiguous route miles containing agriculture increased, lagomorph numbers decreased (Table 13). Clearly, some agricultural development may have a positive effect on lagomorphs and indirectly on raptor numbers and productivity, but results suggest agriculture should be distributed in a mosaic of relatively low acreage rather than extensive tracts of monoculture. In fact, control areas contained large monocultures, and lagomorphs were infrequently observed and generally less represented in raptor food habits.

Nesting phenology of raptors in KRSA was consistent with behavioral and reproductive events in prey populations. Initiation of raptor nesting activity was coincident with emergence of ground squirrels (mid March to early April). Surveys suggest lagomorphs parturated in mid May and late June. Hatching and fledging of raptors occur at these times, respectively, and young, inexperienced lagomorphs subsequently would be more available to raptors experiencing high energy demands (feeding progeny). Also, young ground squirrels become active from mid to late July and presumably present an abundant and readily available food resource to recently fledged, inexperienced raptors.

Movements of raptors in KRSA also reflected behavior and phenology of prey populations. Ferruginous hawks are the most crepuscular of North American buteos and movements of the radio-tagged ferruginous hawk in KRSA were representative. Radio-tagged prairie falcons were active in early morning also, and both they and the hawk were probably responding to early morning activity of potential avian prey species and morning activity of nocturnal lagomorphs within the home range. Mid-day activity of raptors was probably in response to primary activity periods of ground squirrels. Extensive movement of both adult and fledgling raptors away from nest sites in August was consistent with diminishing ground squirrel populations as adult squirrels went underground to estivate. Both FH-738 and PF-338 apparently left the area of Kevin Rim in mid August, probably in response to absence of ground squirrels. Movements of GE-537 were rather confined to within 1-2 km of the nest until tracking ceased in late August. The period of dependence of golden eagles on parental adults often extends to late September or even November post-fledging. Ground squirrels re-emerge in September and October and presumably provide additional food for newly independent golden eagles. The fledgling prairie falcon recovered in southern Alberta (see Raptor Mortalities) probably responded to decreased prey availability in KRSA and wandered farther north. Ground squirrels were most likely more available, longer in the cooler prairie provinces, estivating for shorter periods or not at all.

Effects of Oil and Gas Development

Comparisons of nesting densities between control and KRSA indicate no effect of oil and gas activity on nest site selection and breeding densities of raptors. Breeding densities appear more influenced by physical characters than effects of human activity associated with oil and gas development.

Occupied nest sites of ferruginous hawks and prairie falcons appeared to be selected more on the basis of close proximity to prime nesting and foraging habitat rather than avoidance of oil and gas development activity. Proximity of occupied hawk and falcon breeding sites to oil and gas related HCV's in KRSA were not significantly farther from 25 points systematically located along the rim. This suggests current oil and gas activity has little if any effect on selection or occupancy of hawk and falcon breeding sites.

Occupied great horned owl eyries were closer to all oil and gas development-related HCV's than 25 systematic points on the rim (Table 7), except power lines, but difference was only 23 m and not statistically significant. Human activity around oil and gas wells and tanks was primarily

diurnal. Associated disturbed areas probably facilitated increased prey numbers (microtines, lagomorphs) around tanks and wells, ultimately attracting owls.

The active golden eagle nest in KRSA was considerably farther from active oil wells than systematic points. This was probably more a function of selection for structural characteristics of the nest site and interspecific territoriality rather than avoidance of active oil wells.

Artifacts of oil and gas development had both positive and negative correlations with production of ferruginous hawks and prairie falcons in KRSA. More productive hawk nests were located farther from power lines, possibly due to electrocutions removing breeding adults. Breeding success in raptors increases with age (Newton 1979), and electrocutions and collisions may cause unnatural turnover in breeding ferruginous hawks, reducing success. Productive nests also tended to be farther from active oil wells. Ferruginous hawks are more sensitive than other raptors to human activity (Fyfe and Olendorff 1976) and daily maintenance checks on active wells may be disruptive to nesting birds, manifested in reduced productivity.

Significant differences in productivity of prairie falcons were also related to proximity to oil and gas development structures. Productivity differences, however, were probably more related to structurally less optimal breeding sites rather than proximity to oil and gas activity. More productive eyries were located on more suitable south-facing cliffs of Kevin Rim (Fig. 3), while inactive wells and oil tanks were located primarily to the southeast and east of the rim (Appendix Figs. 8 & 9), closer to structurally marginal eyrie sites. Dirt roads, which were closer to more productive eyries, were in the southwestern portion of KRSA (Appendix Fig. 3). However, prairie falcons often use fence posts for resting and perch hunting, and fence posts commonly line primary dirt roads, aside which ground squirrels also congregate.

Analysis of raptor locations showed little relationship with oil and gas development. PAVR was absent as a discriminating variable in analysis of all 3 groups of locations and reflects lack of paved roads throughout the study area. TRLR was absent from both observed ferruginous hawk and all observed raptor functions and may be a result of ubiquitous distribution of vehicle trails, not necessarily present due to oil and gas development. DRTR and IWEL were absent from analysis of locations of the radio-tagged ferruginous hawk. In nearly all cases, mean minimum distances of raptor locations to each HCV were closer than regular or nonused locations (Table 16). Only proximity to OBLD was significantly ($P<0.05$) greater for the radio-tagged ferruginous hawk, but no occupied buildings were present within the home range of FH-813. Still, absence of occupied buildings in the home range may indicate a strong avoidance of centers of constant human activity but occupied buildings were related to agriculture (primarily ranching), not oil and gas development.

Mean minimum distance to top of Kevin Rim (KRIM) was the most discriminating variable for the radio-tagged ferruginous hawk but not for all ferruginous hawks observed. This was because all incidental locations of ferruginous hawks <800 m from a nest were ignored in analyses to determine characteristics of foraging areas. Eliminating KRIM from consideration, proximity to ground squirrel concentrations was among the top 2 most discriminating HCV for all raptor locations on KRSA.

Locations of raptors away from nests or eyries were more a function of proximity to prey and hunting perches than avoidance of oil and gas development. Proximity to ground squirrel concentrations and power lines seemed to most commonly dictate location of all raptors on KRSA (Table 16). Raptors commonly use power poles as hunting perches, and those located in or near ground squirrel concentrations were probably used intensively and extensively in KRSA.

Data suggest specific oil and gas development structures or activity may affect ferruginous hawks, prairie falcons and great horned owls as manifested in slightly lower productivity. Although possibly contributing to increased turnover rates of breeding adult raptors at specific nests or eyries, powerlines most likely increase survivability of some fledgling raptors and overall productivity of the population. Powerpoles provide elevated hunting perches permitting less energetically expensive foraging and more efficient exploitation of prey resources. Additionally, numbers of raptors found dead below powerlines do not indicate excessive mortality, especially of adults. However, because 2 juvenile golden eagles, at least one locally produced, were found under the same powerline, electrocutions may be eliminating annual eagle production. Every effort should be made to modify offending powerlines to current standards (Olendorff et al. 1981).

Environmental contaminants may pose threats to raptor populations at Kevin Rim but more data are needed to adequately define and evaluate the problem. Mean blood levels of Pb detected in ferruginous hawks were quite high (0.62 ppm), and levels of $\geq$0.2 ppm are indicative of chronic low level or recent acute toxicity (Redig 1985). Pb poisoning reduces fitness of the contaminated organism, often manifested in anemia, reduced immunological response and loss of neurological function (Reiser and Temple 1981). Manifestations such as these were not obvious in raptors of Kevin Rim.

Se levels in blood of $\geq$0.5 ppm have been considered toxic in bovines (Eisler 1985). Raptors sampled in the study areas exhibited Se levels in blood nearly twice that level. Se toxicity in birds is manifested teratogenically (Hoffman et al. 1988) but no deformed nestlings were noted during this study. Productivity per active ferruginous or prairie falcon pair and mean Se levels per brood were not analyzed so effects on raptor productivity are unknown.

Hg appears not to be significant as only one raptor displayed detectable levels in blood. Source and ultimate effects of contamination on local raptor populations are unknown but synergistic effects of contamination with single or multiple toxicants may significantly affect survivability of young raptors.

Distribution and productivity of great horned owls may suggest impacts of hydrogen sulfide (HSO) poisoning. Mortality of great horned owls has been documented in North Dakota from HSO effluents emanating from active oil wells (K. Smith, USFWS, Lostwood NWR, ND pers. comm.). Most great horned owl eyries were located away from active oil well concentrations near Kevin Rim (Fig. 4; Appendix Fig. 7) and productivity was higher at eyries in the control area: an area with no active wells. Wind is seldom absent in the region during daylight hours and any lethal gasses would be quickly dissipated, presenting no threat to diurnal raptors in the vicinity. However, calm conditions often prevail at night. Foraging owls concentrating around active oil wells may be

gassed during calm nocturnal conditions, increasing adult turnover, reducing occupancy and productivity. Certainly more research is needed to determine incidence and severity of gas effluent induced mortality of owls, if any.

Data suggest oil and gas development at current levels probably have mostly beneficial effects on raptor populations at Kevin Rim. However, nesting populations may have already been reduced due to development prior to this study. An area above the rim where a primary access road and oil development were concentrated (southwest 1/4, section 18, T35N, R3W) contained several old, unoccupied ferruginous hawk nests and at least 1 prairie falcon eyrie. These classic breeding sites were apparently abandoned as a result of proximity and intensity of development activity well before initation of this study. Consequently, because analysis involved only occupied nest sites, past disruptive effects of development manifested in abandonment of nests were not obvious. Because ferruginous hawks are the most eclectic of species in choice of breeding sites, oil and gas development may be preventing nesting at sites previously suitable without development, away from the main rim.

Otherwise, development at current levels appeared to have neutral or overall positive effects. Relatively small acreages of disturbed ground plus refuse associated with oil wells, tanks and roads are distributed in a mosaic and are present at low density. These conditions probably promote increased prey populations more widely distributed over natural conditions. Non-agricultural, minimally disturbed ground increases vegetative diversity, providing forage for higher numbers of primary consumers and attracting ground squirrels. Additionally, small, well-dispersed trash/refuse heaps provide cover for lagomorphs, while minimal acreages of agriculture provide prey base with food. Aside from development of new wells and initial construction of new structures, human activity levels associated with oil and gas development are relatively predictable and low. Oil-field workers apparently view raptors with benign indifference. Raptors have apparently habituated to the condition and are able to exploit prey populations in the vicinity of oil and gas development structures at will.

In addition to providing higher, exploitable prey populations, oil and gas development may also effectively insulate raptor populations from significant negative effects related to general public access, recreation and agriculture. Energy fields are generally aesthetically undesirable for recreation, thereby reducing potential for inadvertent and intentional disturbance at nest sites and indiscriminant shooting. Similarly, the Kevin-Sunburst Oil Field inhibits agricultural development of KRSA. Increased agriculture progressing towards monoculture would have a devastating impact on density and productivity of raptors. Density of nesting raptors on structurally similar escarpments 10 km south of Kevin Rim is compelling evidence of the extreme negative effect of agriculture. Tilled fields extend from the base of prime raptor nesting cliffs out several km. Virtually no native grass/shrubland exists and few raptors nest.

MANAGEMENT RECOMMENDATIONS

Applicability of Existing Guidelines

Raptors on BLM lands in the vicinity of Kevin Rim have been managed in accordance with guidelines proposed in the Interagency Rocky Mountain Front Wildlife Monitoring/Evaluation Program Report (USDI 1987). No endangered raptor species nest in the KRSA or control areas but guidelines for Raptors of Special Interest or Concern are applicable (Appendix B). Habitat management guidelines proposed by Call (1979) are also applicable. Based on results of this study however, some guidelines proposed in the above 2 documents should be strengthened, extended, clarified or spatial or temporal specificity added.

Site Specific Management Recommendations

Raptors are most sensitive to human disturbance during nest site selection, nest building/repair, egg laying and incubation periods (Newton 1979) and more likely to abandon nests and nesting attempts when disturbed during these periods (Fyfe and Olendorff 1976, pers. obs.). Response varies with species and individuals but ferruginous hawks are commonly regarded as most sensitive of all North American raptors (Fyfe and Olendorf 1976). Guidelines managing human activity developed for ferruginous hawks could be applied to other raptors nesting at Kevin Rim, thereby insuring adequate protection all species.

Raptor sensitivity to disturbance in nesting phase IV (Hatching and nestling rearing) proposed in Table 2; pg. 36 of Interagency Rocky Mountain Front Wildlife Monitoring/Evaluation Program Report (USDI 1987) should be clarified. Although adult raptors are less likely to abandon nests and nesting attempts when disturbed during this period, guidelines imply effects of disturbance are less severe than during earlier periods. At Kevin Rim, severe weather conditions prevail during phase IV. Adults flushed off the nest during this phase could result in exposure of vulnerable nestlings to lethal effects of wind, rain, snow and sun. In order to promote applicability of Interagency Rocky Mountain Front Wildlife Monitoring/Evaluation Program Report (USDI 1987) to Kevin Rim, modifications to Table 2; pg. 36 should include: table category heading "Sensitivity to Disturbance" changed to Sensitivity and Effects of Disturbance" followed by respective Phase IV category verbage added, "potentially lethal to young nestlings".

Buffer zones around nest sites are especially pertinent to management of raptors to prevent, eliminate or mitigate the disturbing effects of human presence or activity. Human presence and activity are especially disturbing if occurring <u>above</u> raptors and nests (pers. obs.). Buffer zones established for nest sites primarily on the assumption that disturbance may occur only from below may need to be expanded when human activity may potentially occur from above. The summit of Kevin Rim is easily accessible and many raptor nest sites are visible from above, and at proximities that would be disruptive. Consequently, nest site buffer zones at Kevin Rim, especially for ferruginous hawks should be dynamic; expanded for the early nesting season, contracted during late nesting season, both spatially and temporally.

Based on local nesting distribution and phenology (Table 20), total closure of the summit of Kevin Rim within view of any raptor nest or 100 m of

Table 20. Phenological events pertinent to mangement of buffer zones around nest sites of raptors of Special Concern or Interest (Flath 1984) at Kevin Rim.

Raptor Species	Egg-laying	Hatching	Fledging	Dispersal
Golden Eagle	7-15 March	23-30 April	1-7 July	November?
Ferruginous Hawk	23-30 April	22-31 May	7-15 July	10-20 August
Prairie Falcon	23-30 April	24-31 May	1-7 July	7-15 August

rim top above a prairie falcon eyrie should be imposed from 1 March to 15 June. These dates would include sensitive early nesting season through development of young of any species to a stage of thermoregulatory independence. Such a closure should be administratively feasible and acceptable to the public because seldom are weather conditions conducive to recreation at Kevin Rim in spring. From 15 June to 15 July, visits to the edge of the rim within 300 m line of sight of active raptor nests should be managed to less than 30 min. These restrictions may minimize missed feedings and hypo or hyperthermia in nestlings unattended by adults avoiding human presence, and premature fledging of nestlings. Table 21 provides recommended buffer zones proposed in the Interagency Rocky Mountain Front Wildlife Monitoring/Evaluation Program Report and modifications (where applicable) specific to Kevin Rim.

Results suggest that nest site selection and occupancy by raptors at Kevin Rim was not affected by oil and gas development but productivity, especially of ferruginous hawks may have been. Nests of highly productive pairs were nearly twice as far from active oil wells as were nests of pairs with low productivity. This implies a buffer zone of no resource development activity should extend 1 km radius line of sight from ferruginous hawk nests, in order to facilitate maximum production of young hawks. Resource development activity closer to raptor nests may be tolerated if visually insulated from the nest site and no closer than 400 m, but should be evaluated on a case by case basis.

Although data from this study suggests nest site selection was not affected, presence of unoccupied sites in areas of high development indicate the effects have already been manifested. Therefore, mitigative procedures should be implemented. Artificial nesting substrates should be created, i.e. pole/platforms for ferruginous hawks away from escarpments and rocky outcrops and holes created on adequate cliff faces for prairie falcons (Call 1979).

Mortalities of raptors from electrocution were noted and productivity of ferruginous hawk pairs closer to powerlines was lower. All powerpoles within 5 km (at least) of Kevin Rim should be modified to state of the art standards (Olendorff et al. 1981). Such revisions may actually improve survival and productivity of local raptors by providing perches over preferred foraging habitat.

Levels of resource development in the vicinity of Kevin Rim during summer 1990 did not appear to significantly affect raptor population size. However, size and reproductive performance should be monitored at least every 5 years to determine trends and identify problems. Bald eagles obviously avoided human activity spatially and temporally, provided adequate prey base was present and sufficient temporal windows were available to exploit it (Harmata and Oakleaf 1991). As human activity periods expanded, eagles tolerated higher activity levels but productivity decreased. Adequate temporal windows for foraging by raptors, displaced both seasonally and daily from those of humans associated with resource development appeared to exist near Kevin Rim. However, any increase in oil and gas development activity should be monitored and effects on nesting raptors examined. Empirical data concerning responses of individual radio-tagged raptors to resource development activities should be gathered to further refine and develop management tactics at nest sites and foraging habitat, respectively.

Table 21. Recommended buffer zone radii around raptor nest sites for specific activities as proposed in Table 1; pg. 35 of Interagency Rocky Mountain Front Wildlife Monitoring/Evaluation Program Report [RMFR (USDI 1987)] and recommended modifications pertinent to KRSA.

Anthropogenic Activity	Zone Size Recommended (Timing)	
	RMFR	KRSA
Off-road Vehicle Use Camping Hiking Trail Clearing	1/4-1/2 mile	Line of sight on top of rim, 100 m from edge of rim above prairie falcon eyrie, 400 m below nest or eyrie (1 March to 15 June).
Rock Climbing	1/2-3/4 mile	300 m line of sight (for 30 min, 16 June to 15 July).
Road Construction	1/2-1 mile	1 km (1 March to 15 July).
Controlled Burning	1-2 miles	"
Building/construction	1/2-3 miles	Site specific consultation[1].
Mining/heavy equipment or blasting	1-3 miles	"
Logging	1/2-1 mile	100 km of rim, (Never!).
Nonmilitary Aircraft flights (low altitude)	1/4-1 mile	500 m (1 March 15 June).
Low level military aircraft flights	1/4-1 mile	Too fast and too infrequent to present problems at 1990 levels.

[1] On a case by case basis with recognized raptor specialists (i.e. BLM Raptor Research and Technical Assistence Center, Boise District Office.

Every effort should be made to minimize the spread of agricultural crop lands within 10 km of prime raptor nesting habitat (cliffs) near Kevin Rim. Extensive monoculture clearly reduces diversity of vegetative and raptor prey communities, ultimately reducing or eliminating raptor nesting. Additionally, development of any kind should be minimized or intensely managed when proposed for areas near most suitable nesting substrate on the southern-southeastern edge of the Kevin Rim.

Use of organophosphate predicides and rodenticides should be prohibited within 10 km of Kevin Rim due to the real potential of secondary toxicity to scavenging raptors.

Recommendations for Research

1. Continue productivity monitoring, at least 2 breeding seasons every 5 years. Priority should be placed on ferruginous hawks, prairie falcons and golden eagles.

2. Concentrate intensive research on monitoring radio-tagged raptors of all age classes to determine effects of human activity on use of foraging areas, foraging activity and foraging efficiency.

3. Quantify type, intensity, frequency, distance and duration of human activity potentially impacting raptors nesting on Kevin Rim.

4. Investigate the potential effects of HSO gas on great horned owls.

5. Continue monitoring contaminant levels and determine source.

LITERATURE CITED

Anderson, D.E, O.J. Rongstad, W.R. Mytton. 1990. Home-range changes in raptors exposed to increased human activity levels in southeastern Colorado. Wildl. Soc. Bull. 18(2):134-142.

Beebe, F.L. and H.M. Webster. 1964. North American falconry and hunting hawks. North American falconry and hunting hawks. Denver, Co. 313 pp.

Berger, D.D., and H.C. Mueller. 1959. The bal-chatri trap: a trap for the birds of prey. Bird Banding 30(1):18-26.

Brown, L.H. and D. Amadon. 1968. Eagles, hawks and falcons of the world. McGraw-Hill Book Co. New York. 2 Vol. 945 pp.

Call., M. 1979. Habitat management guide for birds of prey. USDI Bur. Land Manage. Tech. Note TN-338, DSC, DFC, Denver, CO. 70 pp.

Dixon, W. J. 1981. BMDP. Statistical software. Univ. Calif. Press., Berkeley. 726 pp.

Dubois, K. L. 1988. Kevin Rim/Sweetgrass Hills raptor survey. Final Report. U. S. D. I., Bur. Land Manage., Great Falls MT. 6 pp.

Dunstan, T.C., J.H. Harper and K.B. Phipps. 1978. Habitat use and hunting strategies of prairie falcons, red-tailed hawks and golden eagles. USDI, Bur. Land Manage. Boise Dist., Boise ID.

Eisler, R. 1985. Selenium hazards to fish, wildlife, and invertebrates: A synoptic review. U.S. Dept. Int., Fish and Wildl. Ser. Biol. Rept. 85(1.5). Contam. Hazard Rev., Rept No. 5. 58pp.

Flath, D.L. 1984. Vertebrate species of special interest or concern, mammals, birds, reptiles, amphibians, fishes. Montana Dept. Fish, Wildl. and Parks. Wildl. Div., Helena. 76 pp.

Fyfe, R. W. and R. R. Olendorff. 1976. Minimizing the dangers of nesting studies to raptors and other sensitive species. Occ. Paper 23. Cat. No. CW 69-1/23. Canadian Wildl. Ser., Ottawa.

Harmata, A.R. and R. Oakleaf. 1991. A comprehensive ecological study of bald eagles in the Greater Yellowstone Ecosystem. Wyoming Game & Fish Dept., Lander. 302 pp.

Hoffman, D.J., H.M. Ohlendorf, and T.W. Aldrich. 1988. Selenium teratogenesis in natural populations of aquatic birds in central California. Archives Environ. Contam. and Toxicol. 17:519-525.

Lund, R.E. 1988. MSUSTAT. Statistical Analysis Package. Res. and Devel. Inst., Inc., Montana St. Univ., Bozeman.

Macdonald, D.W., F.G. Ball, and N.G. Hough. 1979. The evaluation of home range size and configuration using radio tracking data. In C. Amlaner and D. W. Macdonald eds. 1980. A Handbook on Biotelemetry and Radio Tracking: International Conference: Biotelemetry and Radio-Tracking in Biology and Medicine, Oxford, 20 - 22 March. Pergamon. 826 pp.

Meredith, R.L. 1943. Methods, ancient, medieval and modern for the capture of falcons and other birds of prey. Pages 433-449 In C.A. Wood and R.M. Fyfe, eds. The art of falconry. Stanford Univ. Press. Stanford, CA.

Montana Dept. of Fish, Wildlife & Parks. 1984. GEOSCAN users manual. Res. Bur., Box 5, Bozeman. 19 pp. plus appendices.

Newton, I. 1979. Population ecology of raptors. Buteo Books, Vermillion, SD. 399 pp.

Olendorff, R.R., A.D. Miller, and R.N. Lehman. 1981. Suggested practices for raptor protection on powerlines. The state of the art in 1981. Raptor Res. Found., Inc. Res. Rept. No. 4. 111 pp.

Olendorff, R.R., D.D. Bibles, M.T. Dean, J.R. Haugh, and M.N. Kochert. 1989. Raptor habitat management under the U. S. Bureau of Land Management multiple-use mandate. Raptor Res. Rep. No. 8. 80 pp.

Postupalsky, S. 1974. Raptor reproductive success: some problems with methods, criteria and terminology. Pages 21-31 In F. N. Hamerstrom Jr., B. E. Harrell, and R. R. Olendorff eds. Management of raptors. Proc. Conf. Raptor Conserv. Tech., Raptor Res. Rep. No. 2. 146 pp.

Redig, P.T., 1985. A report on lead toxicosis studies in bald eagles. Final Rept. U.S. Dept. of Interior, Fish & Wildl. Serv. Proj. No. BPO #30181-0906. FY 84. 11 pp.

Reiser, H.M., and S.A. Temple. 1981. Effects of chronic lead ingestion on birds of prey. Pages 21-25 In J.E. Cooper and A.G. Greenwood, eds. Recent advances in the study of raptor diseases. Proc. Intl. Symp. on Dis. of Birds of Prey. Chiron Publ., Ltd. West Yorkshire, UK. 176 pp.

Schmutz, J.K. 1987. The effect of agriculture on ferruginous and Swainson's hawks. Can. Jour. Zool. 61(1):60-64.

Snow. C. 1973. Habitat management series for unique or endangered species. Ferruginous hawk. USDI, Bur. Land Manage. Rep. No. 13, DSC, Fed. Ctr., Denver, CO. 23 pp.

Stahlmaster, M.V. and J.A. Gessamen. 1984. Ecological energetics and foraging behavior of overwintering bald eagles. Ecol. Mono. 54:407-428.

USDI (U.S. Dept. of Interior). 1987. Interagency Rocky Mountain Front Wildlife Monitoring/Evaluation Program. Bur. Land Manage., 71 pp.

USDI. 1989. Snake River Birds of Prey Area 1989 annual report. Bur. Land Manage. Boise Dist., Boise, ID. 151 pp.

Webb, R.H. and H.G. Wilshire. 1983. Environmental effects of off-road vehicles, Springer-Verlag, New York.

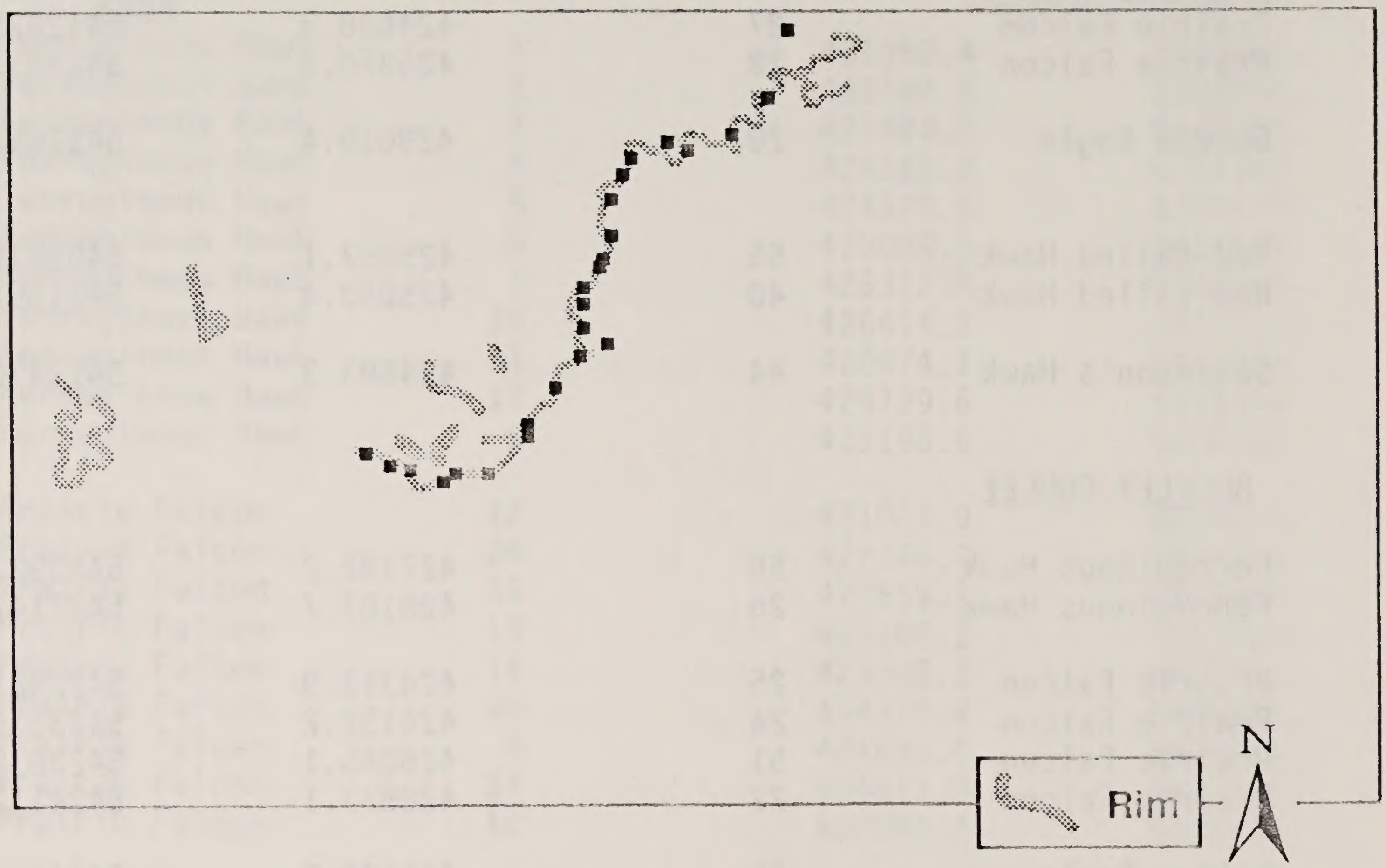
Williams, D.C. and F. Campbell. 1988. How the Bureau of Land Management designates and protects areas of critical environmental concern: a status report, w the Bureau of Land Management designates and protects areas of critical environmental concern: a status report, with a critical review by the Natural Resources Defense Council. Natural Areas Journal 8(4):231-237.

Appendix Table 1. Universal transverse mercator (UTM) coordinates (in decameters) of raptor nest and eyrie sites located on KRSA and control, 1990.

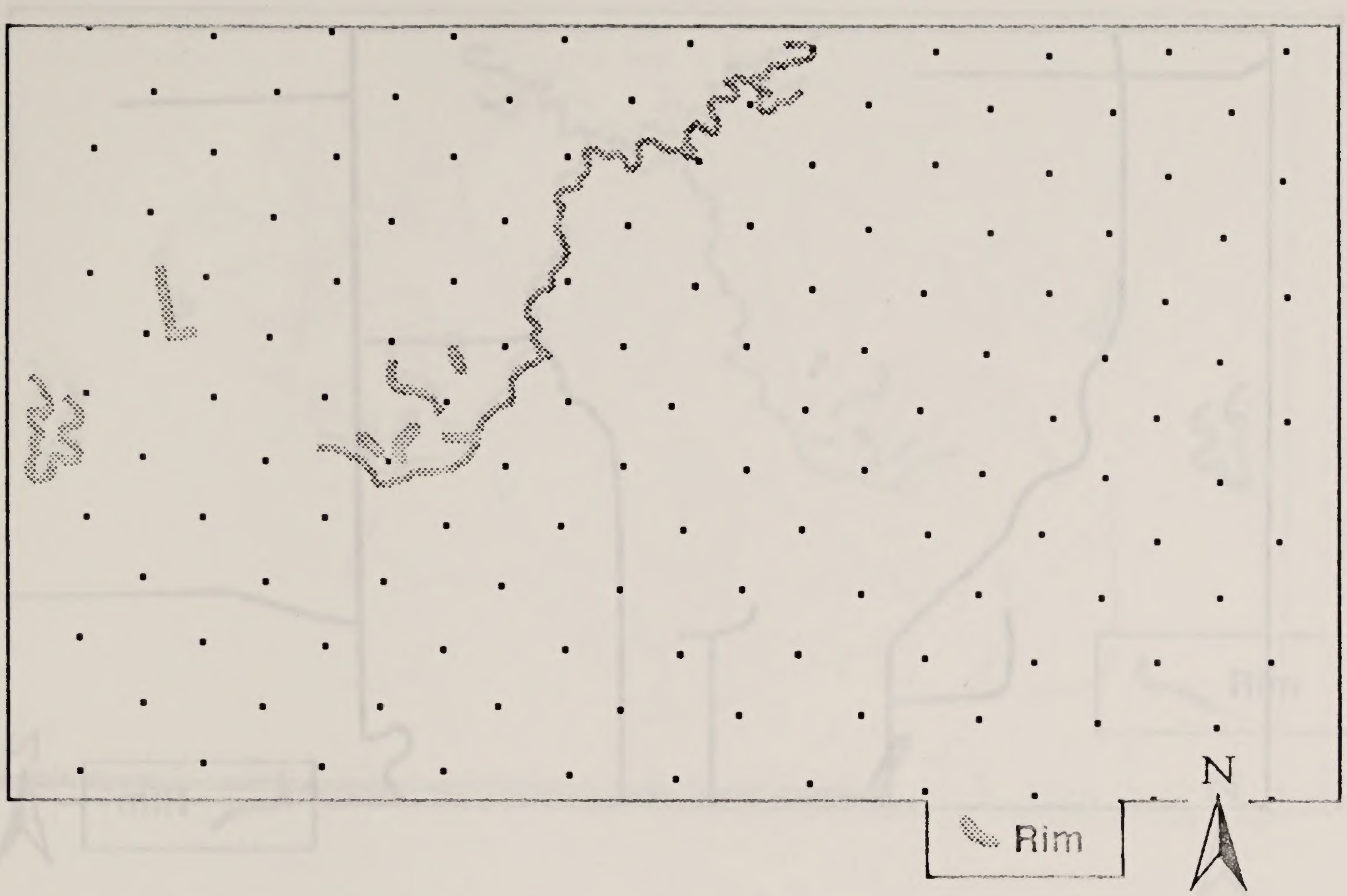
Study Area/ Raptor Species	Site No.	UTM Coordinate Latitude (x)	Longitude (y)
KRSA			
Ferruginous Hawk	1	421352.4	5403800.
Ferruginous Hawk	2	422762.3	5403492.
Ferruginous Hawk	3	423484.8	5403604.
Ferruginous Hawk	4	424122.2	5404848.
Ferruginous Hawk	5	424579.8	5405130.
Ferruginous Hawk	6	425008.5	5405548.
Ferruginous Hawk	7	425312.8	5406116.
Ferruginous Hawk	19	426414.3	5407813.
Ferruginous Hawk	33	426474.1	5407948.
Ferruginous Hawk	17	426729.6	5408324.
Ferruginous Hawk	9	423195.6	5405060.
Prairie Falcon	12	421927.9	5403621.
Prairie Falcon	34	422246.8	5403328.
Prairie Falcon	35	422559.7	5403304.
Prairie Falcon	13	423184.2	5403502.
Prairie Falcon	14	423580.3	5403692.
Prairie Falcon	36	424376.8	5405029.
Prairie Falcon	8	424646.6	5406235.
Prairie Falcon	37	424813.8	5407262.
Prairie Falcon	10	422244.7	5404718.
Golden Eagle	16	423802.3	5404357.
Golden Eagle	18	427099.8	5409339.
Great Horned Owl	11	422067.7	5403558.
Great Horned Owl	15	422900.3	5403460.
Great Horned Owl	53	424416.4	5405818.
Red-tailed Hawk	46	424772.1	5406544.
Swainson's Hawk	45	424545.3	5405684.
BADLANDS			
Ferruginous Hawk	56	425874.9	5409674.
Ferruginous Hawk	54	427340.4	5410203.
Ferruginous Hawk	57	425630.4	5410812.
Ferruginous Hawk	38	424966.3	5412072.
Ferruginous Hawk	29	424447.8	5412678.
Ferruginous Hawk	58	428474.8	5412339.
Ferruginous Hawk	32	428796.5	5412526.
Ferruginous Hawk	31	429984.4	5412946.
Ferruginous Hawk	59	430344.6	5412422.
Ferruginous Hawk	30	430638.3	5412950.

Appendix Table 1, cont'd. Universal transverse mercator (UTM) coordinates (in decameters) of raptor nest and eyrie sites located on KRSA and control, 1990.

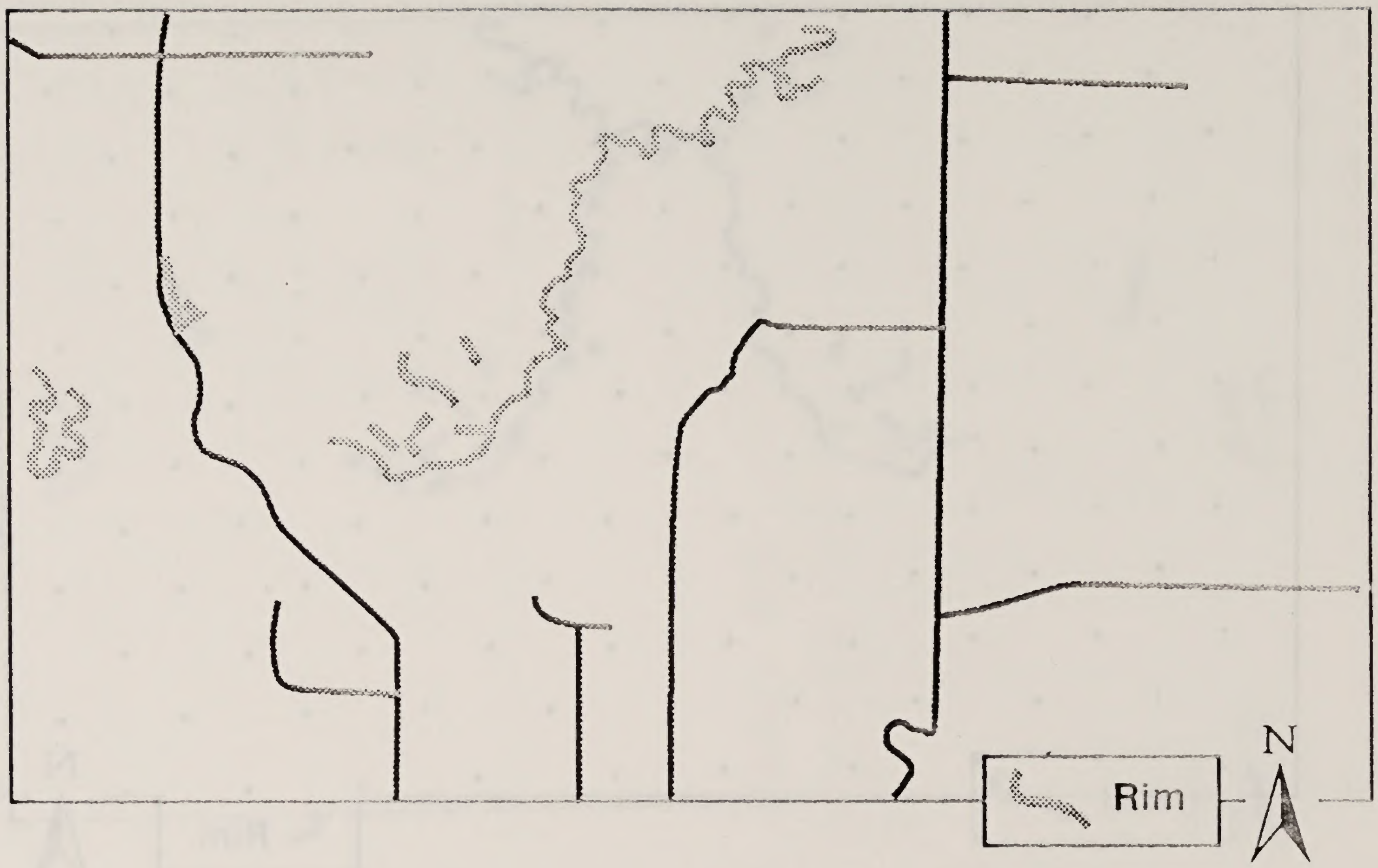
Study Area/ Raptor Species	Site No.	UTM Coordinate Longitude (x)	Latitude (y)
BADLANDS cont'd			
Prairie Falcon	27	424638.3	5412825.
Prairie Falcon	28	425370.3	5413933.
Golden Eagle	20	429619.4	5412696
Red-tailed Hawk	55	425657.1	5409610.
Red-tailed Hawk	40	425053.4	5411307.
Swainson's Hawk	44	424683.3	5412470.
BUCKLEY COULEE			
Ferruginous Hawk	50	427182.2	5423923.
Ferruginous Hawk	26	428107.7	5424147.
Prairie Falcon	25	424313.9	5423981.
Prairie Falcon	24	426152.2	5423555.
Prairie Falcon	51	426845.1	5423838.
Prairie Falcon	22	428833.1	5424112.
Golden Eagle	20	425472.0	5424083.
Great Horned Owl	21	424409.8	5423896.
Great Horned Owl	42	428690.2	5424231.
Red-tailed Hawk	23	423817.8	5423017.



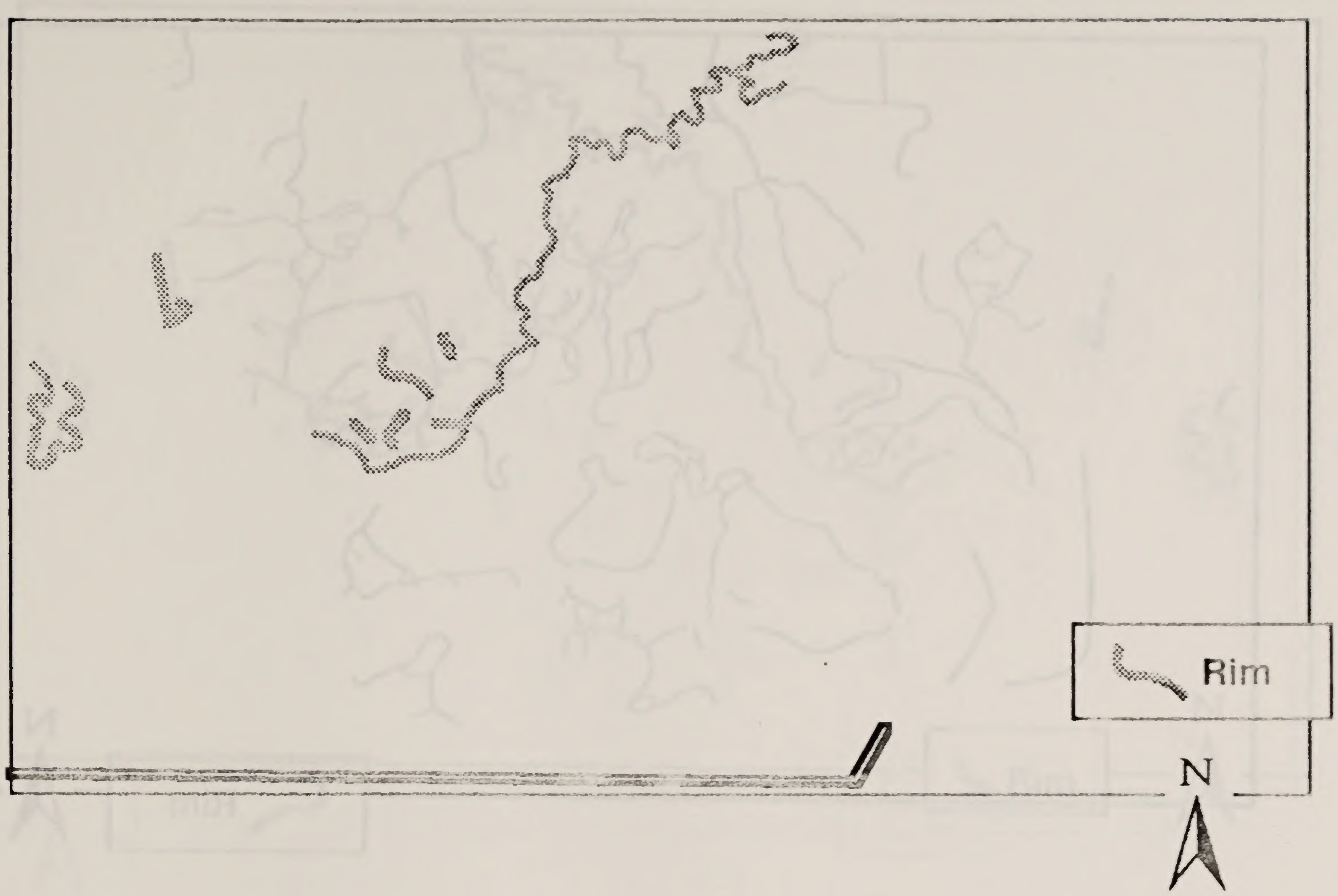
Appendix Figure 1. Distribution of 25 systematically located points of assumed nonnesting by raptors on the summit of Kevin Rim.



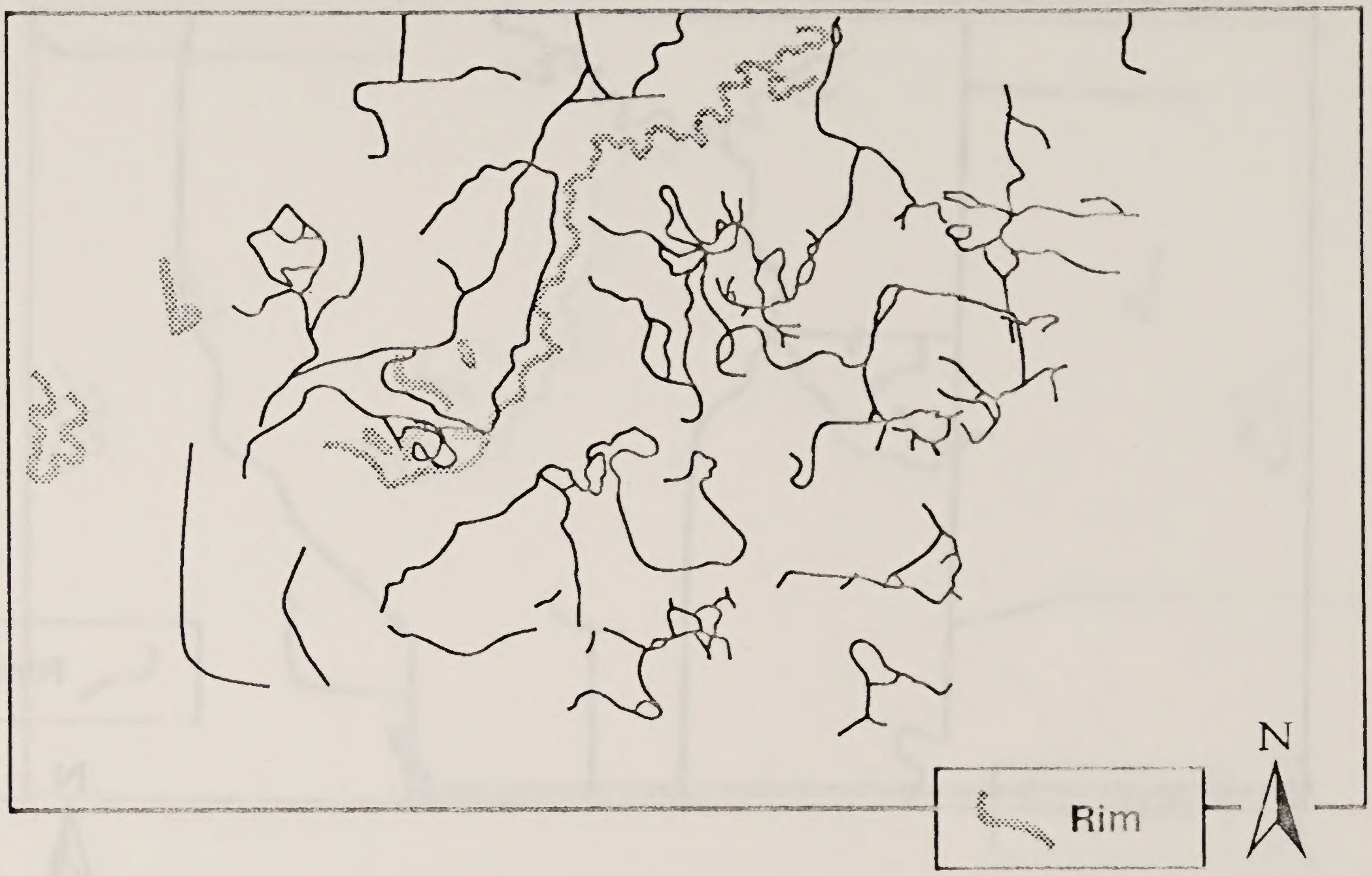
Appendix Figure 2. Distribution of 137 systematically located points of assumed nonuse by raptors in KRSA and control area.



Appendix Figure 3. Distribution of Habitat Component Variable (HCV) dirt roads (DRTR) in KRSA.



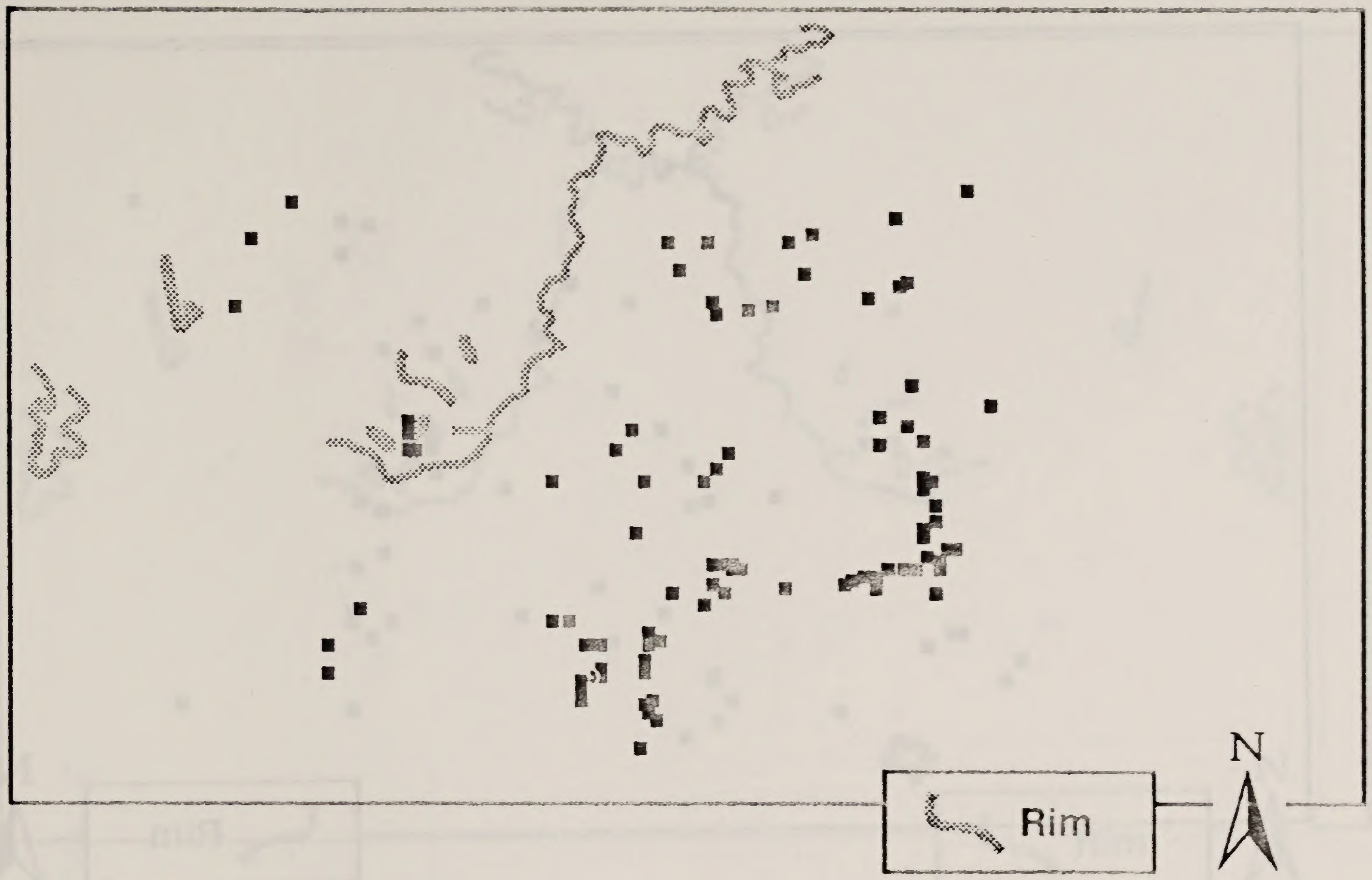
Appendix Figure 4. Distribution of Habitat Component Variable (HCV) paved roads (PAVR) in KRSA.



Appendix Figure 5. Distribution of Habitat Component Variable (HCV) vehicle trails (TRLR) in KRSA.

Appendix Figure 6. Distribution of Habitat Component Variable (HCV) Kevin Rim summit (KRIM) in KRSA.

Appendix Figure 7. Distribution of Habitat Component Variable (HCV) active oil wells (AWEL) in KRSA.

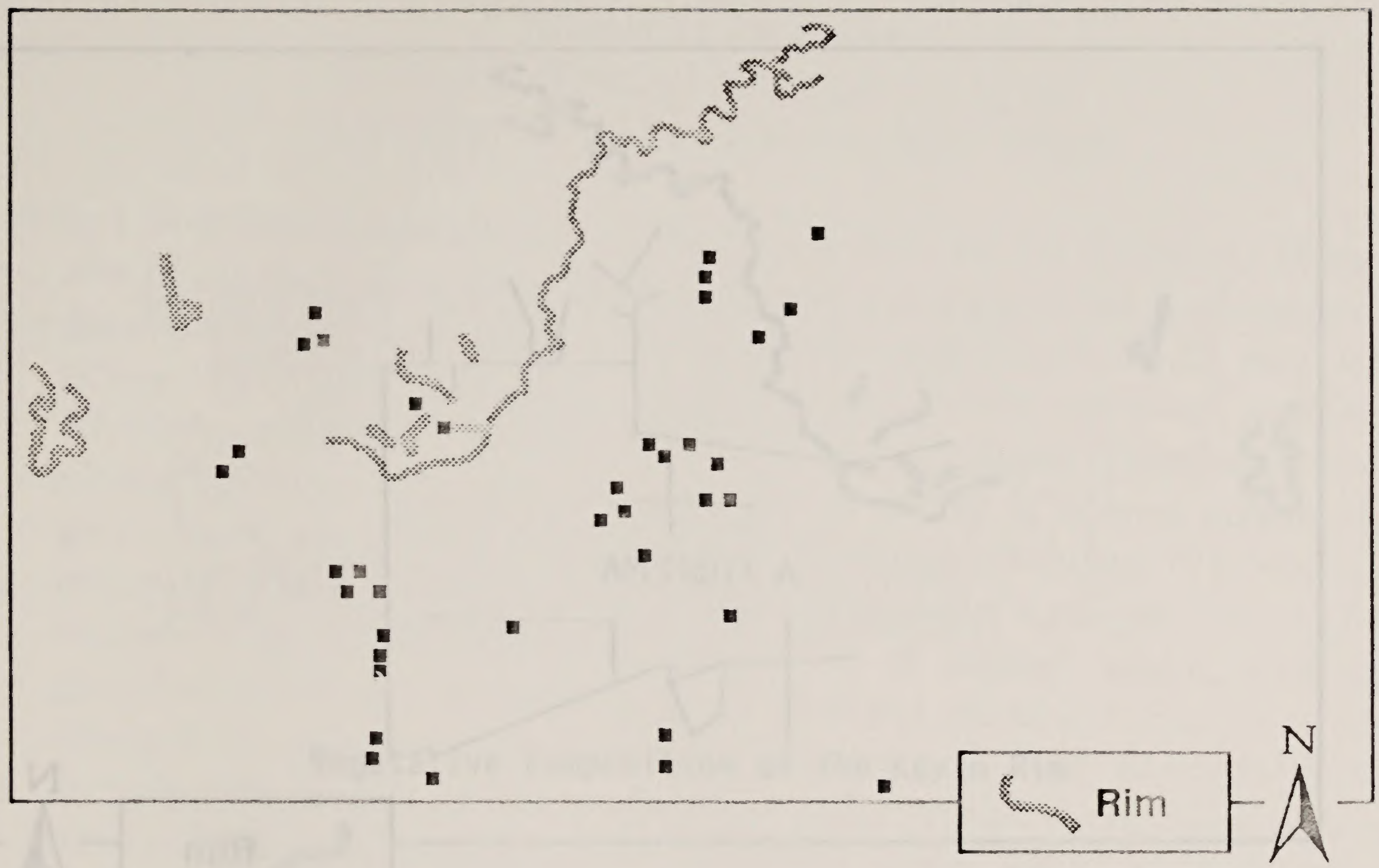


Appendix Figure 8. Distribution of Habitat Component Variable (HCV) inactive oil wells (IWEL) in KRSA.

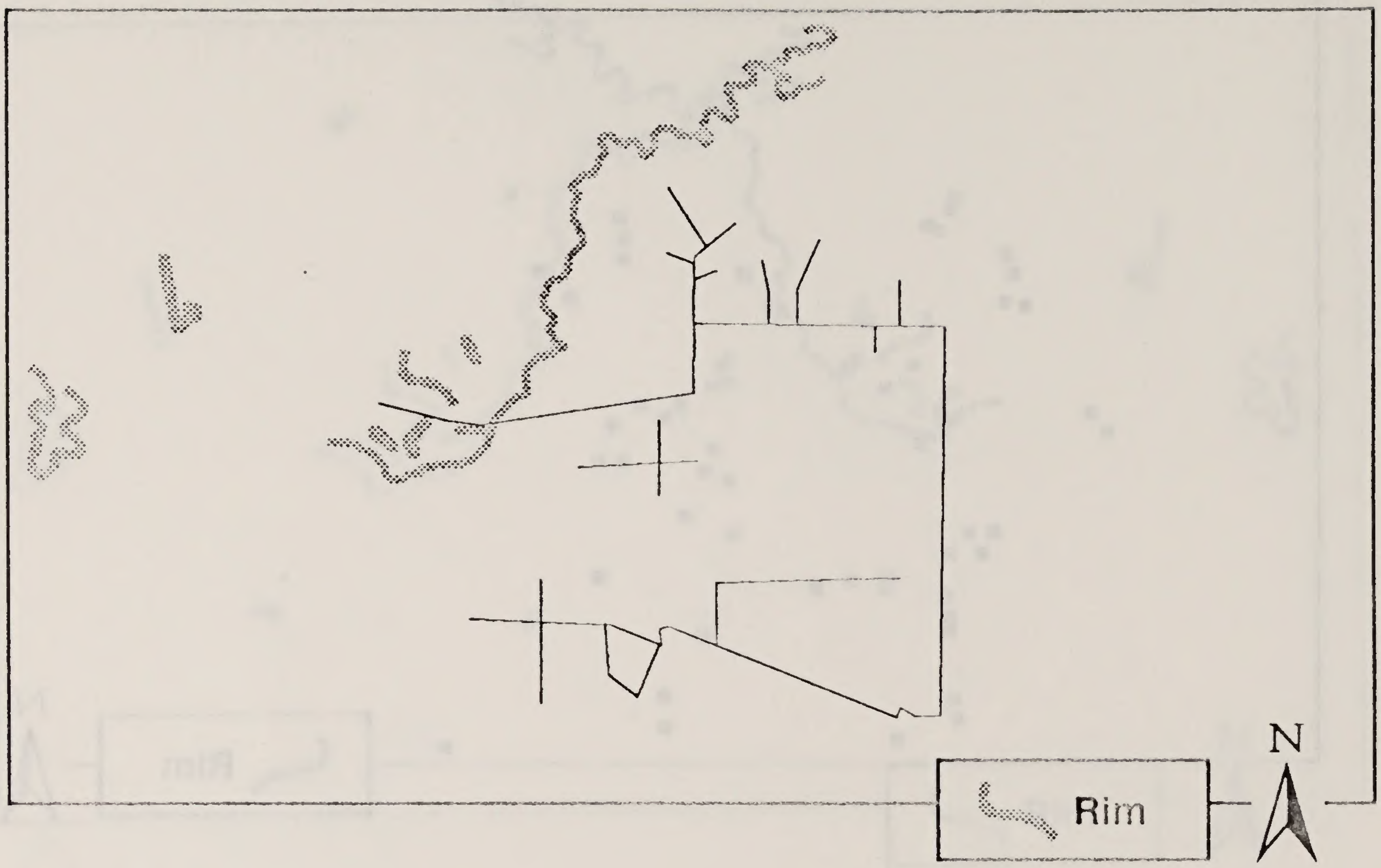
Appendix Figure 9. Distribution of Habitat Component Variable (HCV) oil storage tanks (TANK) in KRSA.

Appendix Figure 10. Distribution of Habitat Component Variable (HCV) occupied buildings (OBLD) in KRSA.

Appendix Figure 11. Distribution of Habitat Component Variable (HCV) abandoned buildings (ABLD) in KRSA.



Appendix Figure 12. Distribution of Habitat Component Variable (HCV) ground squirrel (GRSQ) in KRSA.



Appendix Figure 13. Distribution of Habitat Component Variable (HCV) powerlines (POWL) in KRSA.

APPENDIX A

Vegetative Composition of The Kevin Rim

PLANT COMMUNITIES OF THE KEVIN RIM, TOOLE COUNTY, MONTANA:
Preliminary Survey Results

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Abstract. -- *Plant communities of the Kevin Rim in northcentral Montana are described according to their floristic composition and associated environmental variables. These results are based on 21 reconnaissance "fast-plot" samples located along environmental gradients. Floristic data were grouped into community types based on existing classifications. Results indicate the presence of eleven series (three grassland, six shrubland, and two forest) containing thirteen plant communities. Elevation was ordinated against a subjectively defined moisture index (basically a composite of aspect, slope, and topographic position). Results suggest that the plant communities occur along a complex topographic/soil/moisture gradient. Since total relief is only 800 feet, it is likely elevation relationships are more strongly associated with topographic position than with altitude-related temperature limitations. These results are based on a total of two-days of field work and must be regarded as tentative pending more intensive fieldwork.*

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sourcecode: F90DEV01MTUS

INTRODUCTION

The Kevin Rim in northcentral Montana contains the second highest raptor nest density recorded in the western United States (information on file at MTNHP). At present these raptor populations are being intensively inventoried and monitored as part of a study to determine potential impacts of oil/gas and agricultural development in the area. Additionally, the Bureau of Land Management has proposed a portion of the Kevin Rim be designated an Area of Critical Environmental Concern (ACEC) and the raptor study will provide information relevant to the ACEC designation process.

Although significant knowledge is building regarding raptor populations, plant community composition and environmental relationships at the Kevin Rim have been poorly studied. **Since plant communities constitute a major component of raptor habitat, this survey was conducted.** The objective was to provide a preliminary description of plant community/environmental relationships of the area. The results are based on only two-days of fieldwork (June 20 and 21, 1990) and would require significant additional field survey to validate and refine the community listing and to develop an acceptable vegetation map.

METHODS

The study area was defined as extending from the south-end of the Kevin Rim (T35N, R3W, Sec. 19) north approximately six miles (T36N, R3W, Sec. 20). The study area forms a 3/4 mile-wide band extending approximately 1/4 mile across the mesa-top from the sandstone escarpment and 1/2 mile below the escarpment.

Samples were subjectively selected using a variation of the "gradsect" method described by Gillison and Brewer (1985). The method involved preferential sampling along local transects following the maximum perceived environmental gradients. Representation of the range of elevational, topographic, and soil conditions was strived for. Only two-days were available for fieldwork. An additional, five-days of sampling would likely be necessary to be confident that a representative sample was achieved.

Reconnaissance "fast-plots" were established on different topographic positions along elevational transects where subjective judgement indicated a marked change in vegetation composition. Information recorded included community occurrence acreage (continuous area), topographic position, slope shape, aspect, slope percent, elevation, canopy cover estimates of the five to ten dominant plant species, and general comments regarding the community occurrence.

Analysis focused on using existing plant community classifications to identify plant community types. Direct gradient analysis was used to describe general patterns of communities in relation to environmental factors. Elevation formed one axis of this ordination while the other axis was a subjectively defined moisture index (basically a composite of aspect, slope, and topographic position).

Species nomenclature follows GPFA (1986).

RESULTS AND DISCUSSION

A total of 21 reconnaissance plots were established (Fig. 1). These data were grouped into three grassland, six shrubland, and two forest series containing thirteen plant communities (Table 1). A diagnostic key utilizing indicator plant species is provided for field identification of the plant communities (Table 2).

Community types occur along topographic and soil moisture gradients (Fig. 2). Since total relief is only 800 feet, it is likely elevation relationships are more strongly associated with topographic position than with altitude-related temperature limitations. Descriptions of the 13 community types and their general environmental relationships follow (refer to Fig. 2 also):

Grasslands. The AGSM-BOGR community is common on alluvial fans and other flat to slightly sloping surfaces at low elevations. Heavy grazing by cattle is common and the dominance of *Bouteloua gracilis* likely reflects the species ability to increase in response to grazing. Other characteristic species include *Agropyron smithii*, *Carex filifolia*, and *Artemisia frigida*.

The AGSM-STVI community likely represents a less heavily grazed and/or slightly mesic variant of the AGSM-BOGR community. *Bouteloua gracilis* is often well represented where cattle grazing is moderate to heavy. The community occurs on clayey alluvial fans, flats, and depressions at low elevations. In addition to *Bouteloua gracilis*, *Agropyron smithii*, *Stipa viridula*, *Poa sandbergii*, *Stipa comata*, *Carex filifolia*, and *Artemisia frigida* are generally common to well represented. The most heavily disturbed sites typically feature *Bromus tectorum*.

The AGSP-BOGR community is common on flat to steep slopes at low to mid elevations. Cattle grazing is moderate to heavy and "increaser" plants such as *Artemisia frigida*, *Sphaeralcea coccinea*, *Hymenoxys* spp., and *Phlox hoodii* are often common. Generally, *Bouteloua gracilis* appears to be more abundant on the heavily grazed sites. Other characteristic species include *Agropyron spicatum*, *Stipa comata*, *Carex filifolia*, and *Koeleria pyramidata*.

The AGSP-POSA community is common above the sandstone rim at the highest elevations of the study area. These relatively flat to gently sloping sites have likely received heavy grazing historically both by cattle and sheep. However, no stock were visible at survey time. "Increaser" species such as *Artemisia frigida*, *Phlox hoodii*, and *Selaginella densa* are often abundant. Characteristic species are *Agropyron spicatum*, *Poa sandbergii*, *Carex filifolia*, *Stipa comata*, and *Koeleria pyramidata*. *Bouteloua gracilis* is generally absent.

The FEID-AGSP community is relatively uncommon in the study area and occurs above the sandstone rim on sites similar to the AGSP-POSA community. It is possible that more mesic occurrences of the AGSP-POSA community might represent FEID-AGSP sites where *Festuca idahoensis* has been eliminated by heavy grazing. In addition to *Festuca idahoensis* and *Agropyron spicatum*, characteristic species include *Poa sandbergii* and *Koeleria pyramidata*.

<u>Shrublands</u>. The ARCA/AGSM community is of relatively small extent and occurs in steep mid slope concavities (e.g., draws and other moisture run-on sites). The community represents the driest extreme of "riparian" sites in the study area. The common occurrence of "weedy"

species such as *Bromus tectorum* and *Descurainia pinnata* is suggestive of grazing disturbance, perhaps by sheep. Cattle traffic on these steep slopes is likely infrequent. Characteristic species include *Artemisia cana*, *Agropyron smithii*, and *Elymus cinereus*.

Xeric "badland" sites at low to mid elevations feature vegetation varying widely in composition and cover. Bare soil dissected by gullies characterizes most sites. Perhaps the most characteristic species are *Atriplex nuttallii* and *Oryzopsis hymenoides* and the community is provisionally referred to as ATNU/ORHY (complete community descriptive information would be needed to verify classification). Additional species encountered include *Agropyron spicatum*, *Artemisia cana*, and *Chrysothamnus nauseosus*. Since the cover of forage species seldom exceeds 10 percent and the slopes are often steep, grazing impacts by domestic stock is low. However, even infrequent movement of stock across these unstable sites would likely result in enhanced erosion.

A community provisionally referred to as POFR/AGSP was observed at one location in the study area (complete community descriptive information would be needed to verify classification). The site is a steep, mesic north slope at mid elevation. High species diversity is present (>40 species/tenth acre). Although the grasslands/shrublands below on gentle topography have been heavily impacted by cattle, the steep topography on this site likely prevents cattle form frequently venturing onto the site. Species that are common or well represented include *Potentilla fruticosa*, *Agropyron spicatum*, *Amelanchier alnifolia*, *Juniperus communis*, *Eleagnus commutata*, and *Koeleria pyrimidata*.

Two "riparian" shrubland communities were found in the study area: PRVI and SYOC. The PRVI community is found in upper slope draws and moist concavities and the more common SYOC community occurs in similar habitats at lower elevations. Owing to the greater water availability on these sites, forage production is generally higher than on surrounding uplands. This has generally resulted in higher relative utilization (and impact) by livestock and wildlife on such sites. Increaser species such as *Bromus tectorum* and *Poa pratensis* are often well represented.

Characteristic species in the PRVI community include *Prunus virginiana* and *Symphoricarpos occidentalis*. However, species composition is highly varied among occurrences of this community and *Agropyron smithii*, *Elymus cinereus*, *Artemisia ludoviciana*, *Ribes aureum*, and *Thermopsis rhombifolia* are well represented on some sites.

Symphoricarpos occidentalis characterizes the SYOC community and sometimes dominates stands to the extent that other species are either excluded or are depauperate. Associated species that may be well represented include *Agropyron smithii* and *A. dasystachyum*, and *Artemisia ludoviciana*.

A RHAR/AGSP community occurs on xeric mid elevation sites. Slopes are steep and soils are sandy and erosive with up to 70% bare soil exposed. The physiognomic characteristics are similar to the ATNU/ORHY badlands community which occurs on clayey substrates. Characteristic species include *Rhus aromatica*, *Agropyron spicatum*, *Artemisia cana*, *Oryzopsis hymenoides*, and *Calamovilfa longifolia*.

Forests. Two riparian broadleaved forest communities were found in the study area: PODE/COST and POTR/COST. These communities occupy perhaps the smallest total area of any community in the study area but contain such high species and structural diversity that their biodiversity importance greatly exceeds their area.

The most mesic of the two communities is PODE/COST which was found in a very steep, mid elevation draw. Dominant species present are *Populus deltoides*, *Prunus virginiana*, *Amelanchier alnifolia*, and *Heracleum sphondylium*.

The POTR/COST community was found on a steep north-facing upper slope. Dominant species are *Populus tremuloides*, *Cornus stolonifera*, *Prunus virginiana*, *Amelanchier alnifolia*, and *Ribes lacustre*. The *Populus tremuloides* present features about 30 percent crown mortality (perhaps in response to drought stress?) but appears to be regenerating sufficiently for self-replacement. Species diversity is high (>40 species/tenth acre). The dense vegetation and isolation high up a steep slope has minimized livestock impacts and vegetation condition was among

the most pristine observed. Complete community descriptive information would be desirable to fully document this interesting community occurrence.

CONSERVATION-SPECIFIC COMMENTS

Most of the vegetation present appears to have been impacted by grazing disturbance. At present, livestock do not appear to be intensively utilizing the steeper slopes and vegetation condition may be improving from past impacts (by sheep?) on such sites. However, many of the steep slopes present feature unstable substrates that will likely continue to provide suitable sites for disturbance opportunists such as *Bromus tectorum* regardless of grazing status. Reduction of cattle numbers on the more heavily impacted flat areas below the escarpment may result in improvement in vegetation condition since abundant native seed sources remain.

Conversion of native vegetation to agriculture (i.e., "sod-busting") has occurred on flat topography both above and below the sandstone escarpment. Continued farm expansion may degrade native habitat quality in the area both by reducing the extent of native plant community occurrences and by expanding the seed pool of exotic species.

The network of access roads associated with oil field development and ranching in the area poses a threat to biodiversity. Potential impacts associated with these roads include: disturbances to soils and vegetation resulting from off-road vehicle use, increased poaching, and increasesd dispersal of weeds.

LITERATURE CITED

Anderson, N.L. 1973. The vegetation of rangeland sites associated with some grasshopper studies in Montana. Montana Agriculture Experiment Station Bulletin No. 668. Montana State University, Bozeman.

Gillison, A.N. and K.R.W. Brewer. 1985. The use of gradient directed transects or gradsects in natural resource surveys. Journal of Environmental Management 20:103-127.

GPFA (Great Plains Flora Association). 1986. Flora of the great plains. University Press of Kansas, Lawrence.

Hansen, P., K. Boggs, R. Pfister, and J. Joy. 1990. Classification and management of riparian and wetland sites in central and eastern Montana. Draft Version 2. Montana Riparian Association, School of Forestry, University of Montana, Missoula.

Mueggler, W.F. and W.L. Stewart. 1980. Grassland and shrubland habitat types of western Montana. USDA Forest Service General Technical Report INT-66.

Ross, R.L., E.P. Murray, and J.G. Haigh. 1973. Soil and vegetation inventory of near-pristine sites, Montana. USDA Soil Conservation Service, Bozeman, Montana.

Table 1. Moisture index (1=most mesic; 5=most xeric), elevation (feet), percent slope, aspect, topographic position, element occurrence rank by community type (see code definitions and authority at bottom of table), and plot number.

PLOT	CT	INDEX	ELEV	SLOPE	ASP.	POS.	RANK
GRASSLANDS							
18	AGSM-BOGR	5	3530	5	NE	fan	F
2	AGSM-STVI	4	3660	5	S	flat	C
3	AGSM-STVI	4	3700	8	S	flat	D
1	AGSP-BOGR	5	3600	2	SE	flat	C
4	AGSP-BOGR	5	3840	45	SE	mid	B
9	AGSP-BOGR	5	3540	2	S	flat	C
11	AGSP-POSA	4	4190	3	E	ridge	C
17	AGSP-POSA	4	4250	1	W	ridge	C
21	FEID-AGSP	3	4020	5	E	ridge	C
SHRUBLANDS							
5	ARCA/AGSM	3	3940	20	SE	mid	C
6	ARCA/AGSM	3	4000	40	SE	mid	D
14	ATNU/ORHY	5	3700	5	SE	ridge	B
15	ATNU/ORHY	5	3700	45	S	mid	B
19	POFR/AGSP	2	3780	70	N	mid	B
7	PRVI	2	4060	85	SE	draw	C
12	PRVI	2	4060	50	E	draw	C
8	RHAR/AGSP	4	3960	75	SE	upper	C
16	RHAR/AGSP	4	3900	65	E	mid	B
10	SYOC	2	3580	10	S	draw	C
FORESTS							
13	PODE/COST	1	3960	100	NE	draw	B
20	POTR/COST	1	3920	65	N	upper	B

Table 1. (continued)

AGSM-BOGR:	*Agropyron smithii-Bouteloua gracilis* (Anderson 1973)
AGSM-STVI:	*A. smithii-Stipa viridula* (Ross et al. 1973)
AGSP-BOGR:	*A. spicatum-Bouteloua gracilis* (Mueggler and Stewart 1980)
AGSP-POSA:	*A. spicatum-Poa sandbergii* (Mueggler and Stewart 1980)
FEID-AGSP:	*Festuca idahoensis-A. spicatum* (Mueggler and Stewart 1980)
ARCA/AGSM:	*Artemisia cana/Agropyron smithii* (Hansen et al. 1990)
ATNU/ORHY:	*Atriplex nuttallii/Oryzopsis hymenoides* (not previously described)
POFR/AGSP:	*Potentilla fruticosa/Agropyron spicatum* (not previously described)
PRVI:	*Prunus virginiana* (Hansen et al. 1990)
RHAR/AGSP:	*Rhus aromatica/Agropyron spicatum* (Mueggler and Stewart 1980)
SYOC:	*Symphoricarpos occidentalis* (Hansen et al. 1990)
PODE/COST:	*Populus deltoides/Cornus stolonifera* (Hansen et al. 1990)
POTR/COST:	*Populus tremuloides/Cornus stolonifera* (Hansen et al. 1990)

Table 2. Key to community types of the Kevin Rim.

1. *Populus* spp. with at least 5 percent canopy cover -- 2
1. *Populus* spp. with less than 5 percent canopy cover -- 3

2. *Populus tremuloides* with at least 5 percent canopy cover -- ***Populus tremuloides/Cornus stolonifera*** **CT**
2. *Populus tremuloides* with less than 5 percent canopy cover -- ***Populus deltoides/Cornus stolonifera*** **CT**

3. Shrubs present with a combined canopy cover of at least 10 percent -- 4
3. Shrubs with a combined canopy cover of less than 10 percent -- 9

4. *Potentilla fruticosa* with at least 10 percent canopy cover -- ***Potentilla fruticosa/Agropyron spicatum*** **CT**
4. *P. fruticosa* with less than 10 percent canopy cover -- 5

5. *Artemisia cana* with at least 10 percent canopy cover -- ***Artemisia cana/Agropyron smithii*** **CT**
5. *Artemisia cana* with less than 10 percent canopy cover -- 6

6. *Prunus virginiana* with at least 15 percent canopy cover -- ***Prunus virginiana*** **CT**
6. *P. virginiana* with less than 15 percent canopy cover -- 7

7. *Symphoricarpos occidentalis* with at least 15 percent canopy cover -- ***Symphoricarpos occidentalis*** **CT**
7. *S. occidentalis* with less than 15 percent canopy cover -- 8

8. *Rhus aromatica* with at least 10 percent canopy cover -- ***Rhus aromatica/Agropyron spicatum*** **CT**
8. *Rhus aromatica* with less than 10 percent canopy cover -- ***Atriplex nuttallii/Oryzopsis hymenoides*** **CT**

Table 2. (continued)

9. *Festuca idahoensis* with at least 5 percent canopy cover --
   Festuca idahoensis-Agropyron spicatum CT
9. *F. idahoensis* with less than 5 percent canopy cover -- 10

10. *Agropyron spicatum* with at least 5 percent canopy cover -- 11
10. *A. spicatum* with less than 5 percent canopy cover -- 12

11. *Bouteloua gracilis* with at least 5 percent canopy cover --
    Agropyron spicatum-Bouteloua gracilis CT
11. *B. gracilis* with less than 5 percent canopy cover --
    Agropyron spicatum-Poa sandbergii CT

12. *Stipa viridula* present --
    Agropyron smithii-Stipa viridula CT
12. *S. viridula* absent --
    Agropyron smithii-Bouteloua gracilis CT

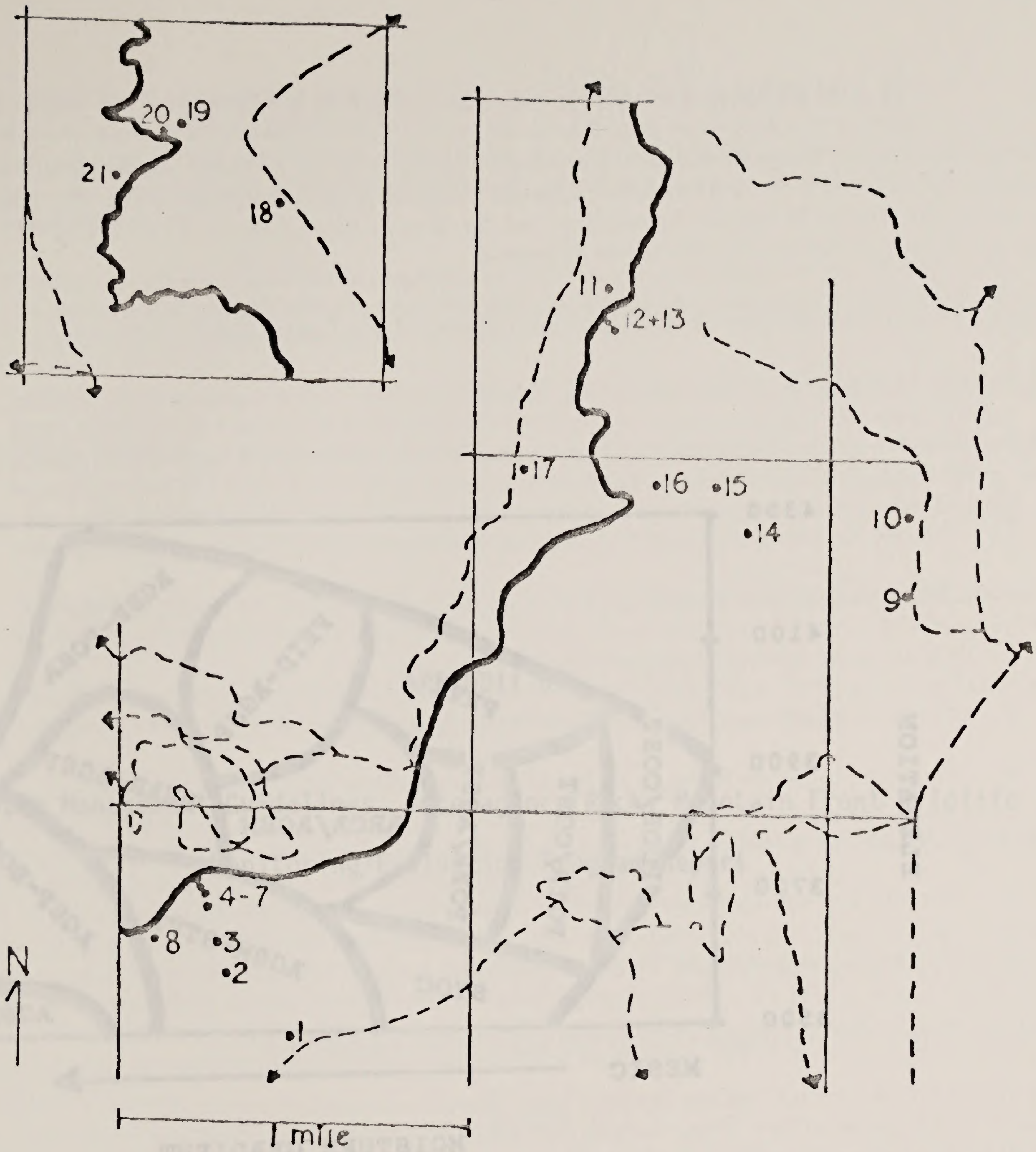

Figure 1. Map of the Kevin Rim study area showing locations of study plots. The square at upper left represents T36N, R3W, Section 20 and the thick black line is the 4000 foot contour. The bottom left (including plots 1 through 8) is the northern portion of T35N, R3W, Section 19 and the thick black line is the 4100 foot contour. The contour lines follow the sandstone rim and the dashed lines represent roads.

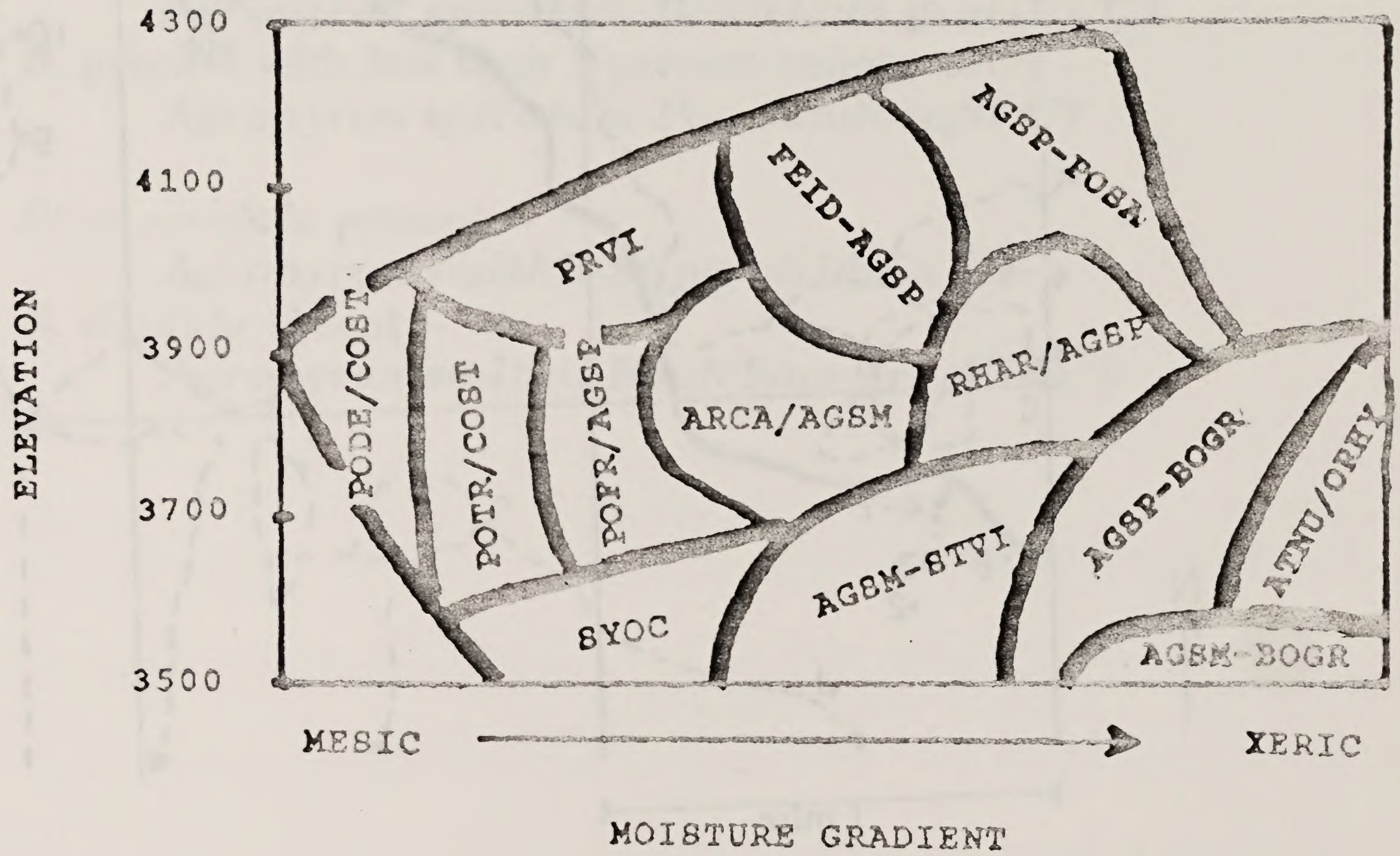

Figure 2. Approximate distribution of Kevin Rim plant communities along soil moisture and elevation gradients. The empty area represents combination that do not exist or are unsampled. Pink, yellow, and no highlighting indicate communities of high, low, and intermediate relative acreage.

APPENDIX B

Raptor Management Guidelines, Interagency Rocky Mountain Front Wildlife Monitoring/Evaluation Program Report

RAPTORS OF SPECIAL INTEREST OR CONCERN

The golden eagle, Cooper's hawk, long-eared owl, northern pygmy owl, northern saw-whet owl, burrowing owl, northern goshawk, ferruginous hawk, prairie falcon and merlin all occur or may occur in the Rocky Mountain Front area and have been identified (by Flath, MDFWP, 1984) as species of special interest or concern in Montana.

Guidelines for Raptors of Special Interest or Concern

CURRENTLY OCCUPIED NESTING HABITAT

1. Avoid human disturbance within recommended buffer zone area (table 1) during sensitive nesting phases (table 2 and table 3).

2. Monitor threats and changes to nesting territories.

POTENTIAL NESTING HABITATS

1. Maintain or enhance riparian habitats.

2. Maintain or enhance special habitat features, i.e., cliffs, snag areas, etc.

3. Manage coniferous forest so as to maintain segments of old growth timber.

NON-NESTING SEASON

1. Identify key use areas, such as migration corridors, winter roosts, foraging areas, etc.

2. Monitor key use areas for threats or change.

Guidelines for Unique or Special Habitat Features

Unique and/or special habitat features lend diversity to environments otherwise dominated by broad plant communities. These habitat features can play on important role in the enrichment of wildlife diversity and wildlife densities in an area. Such is the case in the Rocky Mountain Front Raptor Study Area (DuBois, 1984), where cliffs, riparian areas and coniferous forest were the most commonly used habitats by nesting raptors, yet collectively these habitats comprised only 15% of the total land base.

1. Management activity involving alteration or disturbance of unique or special habitat features should be carefully evaluated on a case-by-case basis.

2. Management should be directed to protection and/or enhancement of all unique or special habitat features.

ENHANCEMENT ACTIVITIES FOR RAPTORS

The following are suggestions for programs that would have the potential to enhance raptor populations on the Rocky Mountain Front.

1. Implement land management plans that perpetually protect and provide habitat important to raptors and their prey.

2. Install artificial nesting platforms in areas of extensive grasslands to provide nesting structures for golden eagles, red-tailed hawks and ferruginous hawks, in areas where it can be demonstrated that populations of these species will benefit without impacting other special interest species (such as black-footed ferrets and Swainson's hawks) through predation or competition.

3. Encourage planting and maintenance of shelter belts in agricultural areas. Shelter belts have the potential to provide nesting areas for Swainson's hawks, red-tailed hawks, merlins, great horned owls and long-eared owls.

4. Install dikes to retain water on areas that are presently exposed as mud flats on the upper ends of reservoirs which are severely dewatered during the summer (Eureka, Bynum and Nilan Reservoirs). This would greatly enhance waterfowl and shorebird production which would in turn provide a better prey base for prairie falcons and peregrine falcons. This would also reduce blowing dust from these areas. Islands should be constructed in the dike ponds to provide nesting areas for waterfowl.

5. Revegetate clear-cuts and disturbed areas with a diversity of native plants, and encourage reseeding of highly erodible croplands to native vegetation to maintain a diverse prey base.

6. Implement a snag management policy that will provide nesting habitat for cavity-nesting raptors such as American kestrels and saw-whet owls.

The failure of adult raptors to return to the nest, eggs or young after human interference of an unfamiliar nature is both serious and unpredictable. Because of this unpredictability, precautions should always be taken around any occupied nest or potential nesting territory.

Following are general recommended nest buffer zones related to various human activities. These activities and recommended zones are not inclusive, details of terrain, vegetation, type and duration and familiarity of disturbance, specific temperament of individual birds, phase of nesting cycle, etc., all enter into determining the actual needed buffer zone at a given nest site. Preclusion of human activity at a given nest territory should be tempered with as many variables as possible, and on a site specific basis.

Table 1

Activity	Recommended buffer zones
Off-road vehicle use	1/4 mile - 1/2 mile
Camping	1/4 mile - 1/2 mile
Hiking	1/4 mile - 1/2 mile
Rock climbing	1/2 mile - 3/4 mile
Road Construction	1/2 mile - 1 mile
Controlled burning	1 mile - 2 miles
Trail clearing	1/4 mile - 1/2 mile
Building/construction	1/2 mile - 3 miles
Mining/heavy equipment or blasting	1 mile - 3 miles
Logging	1/2 mile - 1 mile
Aircraft flights (low altitude)	1/4 mile - 1 mile

Nesting chronology for most raptors can be divided into 5 phases. The following summarized each phase, general sensitivity to disturbance and comments. This table should be used with table 1 to temper activity and zone buffers.

Table 2

PHASE	ACTIVITY	SENSITIVITY TO DISTURBANCE	COMMENTS
I	Nest building includes courtship behavior	Extremely Sensitive, period most likely to desert.	1. Most critical time period from the standpoint of desertion.
II	Egg laying	Extremely Sensitive, period most likely to desert.	2. Human disturbance of even limited duration may cause desertion, not only of nest sites, but also of long established territories.
III	Incubation	Extremely Sensitive, period most likely to desert.	3. Nest site tenacity is weakest on new territories or when the birds first establish their territories. 4. Flushed birds may puncture, crush or eject eggs from nest. 5. Flushed birds leave eggs unattended. Eggs are susceptible to cooling, loss of moisture, over heating and predation.
IV	Hatching and nestling rearing	Moderately sensitive	1. As hatching/rearing approaches, most birds become tenacious to clutches of eggs. 2. Generally, uncommon to desert a nest after young have hatched.
V	Post fledging	Moderately	3. First half of nestling period, young most susceptible to elements. 4. Flushed birds may trample young or eject them from nest. 5. Unattended nestlings may chill or overheat, are susceptible to predation. 6. Nestlings may miss feedings. May affect overall health of young birds. 7. Premature Fledging Threat to young prematurely leaving nest [illegible]

Approximate nesting dates for some raptors that occur in the Rocky Mountain Front, North central Montana.

Table 3

Species	Approximate Dates of Nesting Season
Turkey vulture	April 15 - August 1
* Golden eagle	February 1 - July 30
** Bald eagle	February 15 - August 15
Northern harrier	April 1 - July 15
Sharp-shinned hawk	April 15 - August 15
* Cooper's hawk	April 15 - August 15
* Northern goshawk	April 15 - August 15
Red-tailed hawk	April 15 - August 15
Swainson's hawk	May 1 - September 15
* Ferruginous hawk	April 1 - July 30
American kestrel	May 1 - August 15
* Merlin	April 15 - August 15
* Prairie falcon	March 15 - July 30
** Peregrine falcon	April 15 - August 1
Short-eared owl	March 1 - August 1
Long-eared owl	March 1 - August 1
Great horned owl	January 1 - August 1
Great gray owl	March 1 - August 15
Eastern screech owl	March 1 - July 1
Northern pygmy owl	March 1 - July 15
* Northern saw-whet owl	March 1 - August 30
* Burrowing owl	March 15 - July 15

*Species of Special Interest or Concern
**Federally Listed Species